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A USAF ENERGY CONSUMPTION PROJECTION
MODEL

W. D. Gosch, et al

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direct support energy (that used by ground
support and other related equipment), and
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The direct energy is identified by program
element, program, and type of fuel. Direct
support and ancillary support energy is estimated
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A USAF Energy Consumption Projection Model

W. D. Gosch and W. E. Mooz

A Report prepared for

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Rand
SANTA MONICA, CA. 90406

PREFACE

The United States Air Force is not only a sizable consumer of
energy but also a conspicuous one, since most of its energy use is
related to flying. If the Air Force should desire to reduce its
energy consumption, what is the best way to do it? How is future
energy consumption by the Air Force related to the programmed activities
of the force? How can alternatives to programmed activities be
examined with regard to their energy use? At present, questions such
as these cannot be answered without laborious calculations and
estimates.

This report discusses a computer model that can be used to project
future energy needs for the Air Force based on force posture elements
and operational activity. The model gives Air Force planners a rapid
method of systematically comparing the energy impact of present and
alternative programs, the effects of changed flying activities, and
current and hypothetical weapon systems. It should thus be particularly
useful to those who are responsible for long-range planning decisions
affecting energy consumption by the U.S. Air Force, the dominant
consumer of petroleum products within the Department of Defense.

This research was performed as part of a Rand study of energy
availability and national security, sponsored by the Defense Advanced
Research Projects Agency. The computer model is being used by Rand
in this ongoing research. In addition, a preliminary copy of the
computer program was sent to the Computer Applications Group Office,
Assistant Chief of Staff/Studies and Analysis, Hq USAF.

SUMMARY

The computer model discussed in this report was specifically de-
signed for Air Force planners and uses program information as inputs in
a format familiar to them. The outputs appear in program format, with
each program element identified. The energy estimates are made in the
categories of direct energy (that used by the prime mission equipment),
direct support energy (that used by ground support and other related
equipment), and ancillary support energy (that used on bases). The di-
rect energy in the output format is identified by program element, pro-
gram, and type of fuel. Direct support and ancillary support energy is
estimated for the entire Air Force in terms of Btu and type fuel, so
that the results may be examined in terms of total energy (Btu) or in
terms of the physical quantities of each type of fuel (tons of coal,
gallons of jet fuel, etc.).

The design of the model allows the introduction of hypothetical
weapon systems as well as existing systems, so that estimates may be
made for future forces. Provisions were made to accommodate conven-
tionally fueled weapon systems as well as those which might use uncon-
ventional fuels. The fuel consumption of hypothetical weapon systems
may be input directly, if known, or may be internally estimated by en-
ergy estimating relationships (EERs). A set of typical EERs was devel-
oped in the course of the study and either it or another of the ana-
lyst's choice may be used.

The work which preceded the development of the model showed that
the Air Force presently uses about 1000 trillion Btu of energy per year.
Of this, about 75 percent is direct energy, 6 percent is direct support,
and 18 percent is ancillary support. Energy use is strongly related to
flying hours, but the relationship is often subtle, due to the differ-
ent consumption rates of the various aircraft. For example, the stra-
tegic forces account for about 13 percent of the flying hours, but con-
sume 31 percent of the direct energy. The largest energy users are
cargo/transport, followed by fighter/recon and bomber/recon type air-
craft. The three single largest users of energy in 1972 were the C-141,
B-52, and F-4 aircraft.

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I. INTRODUCTION

Modern warfare inherently requires large amounts of energy for operating military weapon systems. The ability to use these weapon systems effectively in times of war requires that military proficiency be maintained during times of peace--a process that in itself constitutes a continuing use of energy. The Department of Defense (DoD) accounts for about 28 percent of the U.S. governmental budget expenditures, and the Air Force accounts for about 9 of this 28 percent. It is thus rea-sonable to expect that the amount of energy used by these organizations is significant in terms of the total use of energy in the United States. The data for 1971 show that almost 4 percent of the total U.S. petroleum consumption was used by the DoD, including 53 percent of the total U.S. jet fuel consumption. Of this, the Air Force accounted for approximately half of the total. The Air Force thus has been and probably will continue to be a significant consumer of energy in the United States.

Recent events in the United States and elsewhere have demonstrated that our domestic supplies of energy, particularly petroleum, are insufficient for present demands. The establishment of a Federal Energy Administration and the subsequent results of their work and others emphasized that future energy use must be carefully planned in order to be in accord with national objectives. The energy demands of the wide planning options open to the Air Force have probably never assumed the importance that they have today. For example, airborne alert requires more fuel than the conventional ground-alert configuration; a strategic offensive force of missiles, dormant in their silos, requires less fuel than either form of bomber alert; and forward basing implies different uses of energy than strategies which rely upon quick responses from the U.S. mainland.

While these qualitative assessments may be easily made, the quantitative effects may be calculated only with difficulty at the present time. What is required is a tool by which simple and systematic comparisons between alternatives may be made so that their effects upon

energy consumption may be evaluated. With such a tool, planners would be better equipped to plan for an effective Air Force in an energy-constrained environment, while being more aware of their options should a requirement for decreased energy use be levied upon them.

This report addresses the need for a tool to deal with the energy demand aspects of alternative force postures and describes a computer model which was constructed to systematize the method and facilitate the projection of energy demands by the Air Force. It has been designed for use by planners and others familiar with dealing with USAF program information, permits the rapid estimation of the energy requirements of any program, and allows the energy demands of alternative programs to be compared. The model can answer many types of questions related to both the short-term and long-term use of energy. These may be as simple as estimating the energy effects of a change in training flying hour schedules or substituting one design aircraft for another on a specific mission, to as complex as analyzing the long-term energy effects of a proposed new weapon system or changes in the ratios of strategic and general purpose forces. In general, the energy effects of any program change which involves modifications in the type, number, or activity rate of the weapon systems may be estimated.

The model estimates only the energy consumed in operating the Air Force; it does not include energy requirements for the manufacture of aircraft or for any other civilian industries which operate in support of Air Force activities. The question of how much energy is used, and by whom, is covered in detail in R-1448-ARPA, *Energy Consumption by Industries in Support of National Defense: An Energy Demand Model*, by C. C. Mow and J. K. Ives, March 1974. In that report the pervasiveness of the needs of the Department of Defense upon the civilian economy is demonstrated, and the indirect energy demands of DoD upon the civilian suppliers are estimated.

II. HISTORIC USE OF ENERGY BY USAF

This section provides information on data sources, describes the practical limitations of some of the data, and gives a perspective of the Air Force's use of energy.

SOURCES OF DATA

Prior to the events that precipitated the recent energy crisis, data on energy and fuels used by the Air Force were routinely reported by the Defense Fuel Supply Center (DFSC) and the Air Force Directorate of Civil Engineering. The DFSC received Quarterly Petroleum Products Status and Program Reports from each of the three services--Army, Navy, and Air Force--in a standardized format known as Form 531. Eight types of petroleum products were reported:

- o Aviation gasoline--all grades
- o Jet fuel--all grades (JP-4, 5, 6, etc.)
- o Motor gasoline--all grades
- o Distillate fuels--all grades of diesel fuel, kerosene, #1 and and #2 fuel oil, but excluding Navy distillate fuel oil
- o Residual fuels--all residual fuels, including #4, #5, and #6 fuel oils and equivalents, but excluding Navy special fuel oils
- o Navy special fuel oil
- o Navy distillate fuel oil
- o Other (RP-1)

Early reports gave data on the actual or estimated quarterly status of petroleum products in terms of inventories, receipts, and utilization for the current fiscal year plus a summary of actual consumption for the previous fiscal year. In addition, a projection for the next fiscal year's requirements was made. The data from these quarterly reports[1-4] were used to determine historical energy consumption for the Air Force. Quantitative data for these petroleum products are given later in this section for fiscal years 1968 through 1973.

The Air Force Directorate of Civil Engineering compiles cost and quantity data on energy use according to Civil Engineering cost account codes.[5] Included in this compilation are quantitative data on ancillary support energy consumption. The four energy forms of interest here are purchased electricity, natural gas, solid fuel, and fuel oil. Quantitative data on these energy forms were obtained from the Directorate of Civil Engineering* and are given later in this section for fiscal years 1968 through 1973.

During 1973, the Defense Energy Information System (DEIS) was set up to monitor all facets of energy supply, inventory, and use for the Department of Defense. This is an extremely detailed system normally capable of supplying all of the information required for a study such as this from a single source. Unfortunately, the historical information required for this study was not available from DEIS, and the data needs had to be satisfied from the traditional sources which the DEIS now replaces. The advantage of DEIS is that it combines a variety of independent data gathering functions into a single integrated activity, with all information being collected and reported on a consistent basis. Future studies of this type will benefit markedly from the system.

DATA LIMITATIONS

Although detailed data on all forms of energy consumed by the Air Force were doubtless recorded at some time in the past, in the absence of an "energy crunch," it was not generally important to specify the actual end use of a particular product. Whether jet fuel was used to fly airplanes or heat a barracks at a remote airfield was of little consequence. Projections of future needs were often based on past experience, and detailed breakouts of end use, when available, were aggregated to a high level such as a command or military base, which in turn would report to even higher authority. Frequently detailed supporting input data that were used for the aggregated totals were recorded only temporarily and then became unavailable for later in-depth analysis.

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*Reference 6 and personal communication on cost data, FY 1972-1973, purchased and generated energy, received from Systems Engineering Branch, Directorate of Civil Engineering, Department of the Air Force, October 1973.

The data base for the model discussed here spans fiscal years 1968 through 1973. These years were chosen because DFSC could provide data on petroleum products consumption over this period of time. Also, the major source of energy (direct energy) for the Air Force is jet fuel and aviation gasoline for aircraft operations, all of which is accounted for by DFSC.

Although consumption data for petroleum products other than jet fuel and aviation gasoline are also reported by DFSC, the actual end use of these products is not nearly as clear-cut as that of aviation fuels. Consequently, the allocation of energy quantities to direct support or ancillary support was a matter of deciding which category used the major portion of the energy.

Data for ancillary support energy was particularly difficult to determine. The lowest level of aggregation available was at the command level. For example, purchased electricity data were reported for the larger consumers, such as the Strategic Air Command and Logistics Command, down to the smaller consumers, such as the Aeronautical Chart and Information Center and Communication Service Command. In all, there are 20 commands on which data were obtained from the Air Force Directorate of Civil Engineering over the six years from 1968 through 1973 for purchased electricity, natural gas, solid fuel, and fuel oil. There were a number of holes in this data matrix and it was necessary to estimate the missing values.

ENERGY CONSUMPTION

Figure 1 illustrates the historic use of energy by the Air Force from 1968 through 1973. The graph illustrates the consumption of energy by each major type, as well as the total. It is apparent that the largest single form of energy used is jet fuel, and that the various other forms of energy contributed in much smaller amounts to the total. Consumption of all energy forms has been approximately constant in the last three years at about 1000 trillion Btu, down from a prior level of about 1200 trillion Btu.

The same information is displayed in Fig. 2 as a percent of total USAF energy, and is plotted cumulatively, for each year, so that the
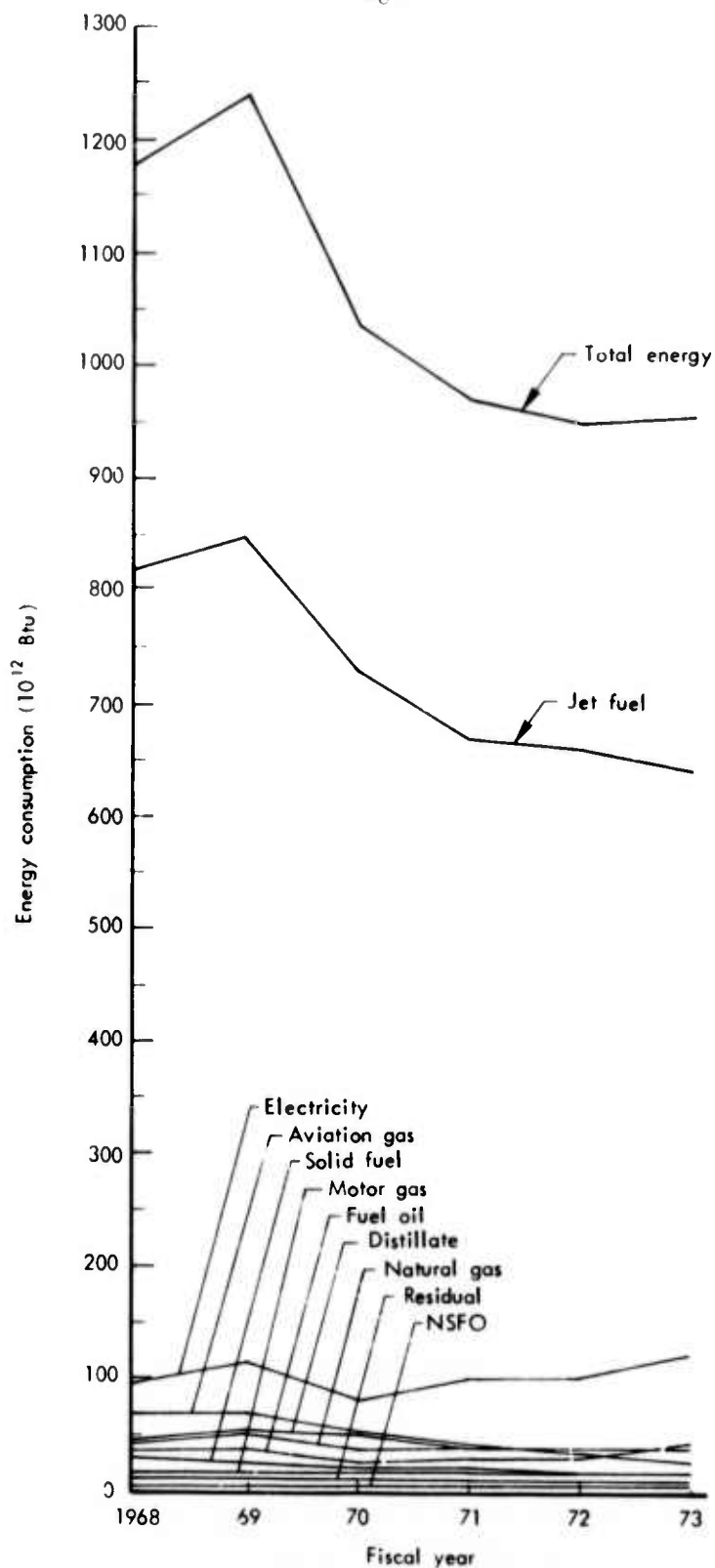
Fig.1 — Historical use of energy by USAF
FY 1968 – FY 1973
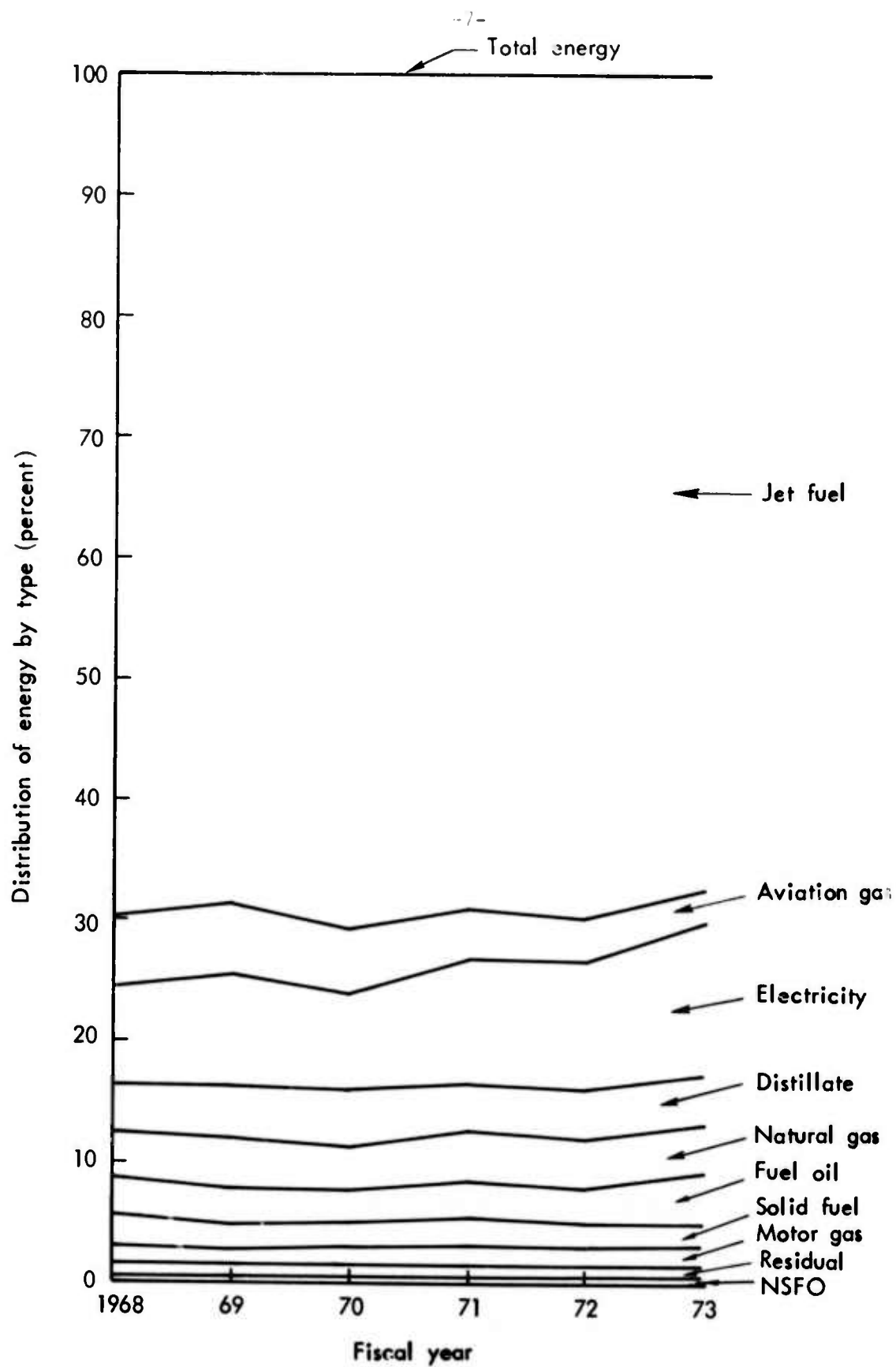
Fig.2 — Distribution of USAF energy by type
FY 1968 - FY 1973

share of total energy contributed by each form is more clearly illus-
trated.

While it is informative to examine the historical consumption of
each energy form, this provides little insight into the reasons behind
the use of the energy and insufficient background to construct a model
for projecting demands. Consequently we have restructured the energy
consumption data in a more useful format, according to end use.

Energy is used by the Air Force in a wide variety of applications
that include the fuel for operating aircraft, trucks, cars, and ground
equipment, fuels for space and hot water heating, electricity for lights
and air conditioning, and even fuel for boats. For the purpose of de-
scribing the use of energy by the Air Force, we have devised three cat-
egories which are based upon the purpose for which the energy is used.
Within each of these categories it is possible to subdivide according
to the type of fuel used, and this has been done to the extent that the
data allow. A description of the categories follows:

Direct energy is energy used by prime mission equipment (PME),
e.g., aircraft and ballistic missiles.
Direct support energy is energy consumed in direct support of the
PME, e.g., AGE and motor vehicles.
Ancillary support energy is energy required by bases and other
facilities in support of the PME, e.g., heating and lighting.

Use of this categorization simplifies the analysis of energy being
consumed and focuses on the role of the prime mission equipment as the
major energy consumer. Further, it correctly stratifies the energy
use. Direct energy is that used by the weapons; other categories of
energy are used only in support of the use of the weapons.

The definitions of direct energy, direct support, and ancillary
support are clear. However, some problems are encountered in dealing
with the data as well as with the philosophy of division among the
categories. For example, the data report the total consumption of
diesel fuel, but do not report what it is used for. We find that most
of it is used for motive purposes, and consequently this portion may

be considered direct support energy. However other portions are used for heating (ancillary support) and electricity generation. This last purpose could be classed as ancillary support, except that in the case of supplying ICBM complexes, the energy falls into the direct category. We have attempted to make the divisions where possible, and where it was not possible to apportion between direct and ancillary support, the energy was included under the category where most of the fuel form appeared. Errors of division in this way are not large and have little significance in the context of total energy demand projections.

Having defined these categories, we can now replot the information in Figs. 1 and 2 according to the end use of energy. Figure 3 shows the absolute amounts of energy used and indicates what might be expected-- the direct energy category is the largest. This is further quantified in Fig. 4, where the data are displayed in percentage form. From Fig. 4 it is apparent that the relative distribution of energy among the three end uses has been relatively constant over time. This observation has been extrapolated to the assumption that the distribution not only will remain constant in the future, but also that both forms of support energy are a function of the direct energy. Making this assumption provides a simple basis for projecting the demands for support energy once the demand for direct energy is known. Conceptually, relating support energy to direct energy is satisfactory in aggregate terms. It could be argued that the ancillary support energy might be more precisely related to other factors as well, such as the number of bases, manpower levels, base locations, etc. While this may be true, projections of ancillary support energy made by a simple relation to the direct energy may only be nominally different from those made using more inputs. Again, the objective of this effort was to provide a tool by which energy comparisons of alternatives could be systematically and rapidly compared. The need for unnecessarily complex inputs was to be avoided, and the simple relation of support energy to direct energy satisfied the criterion for simplicity, while maintaining a conceptually sound basis for making comparisons between cases of interest.

The data allow the information in Figs. 3 and 4 to be disaggregated by fuel type. This diseggregation appears in Figs. 5 and 6,
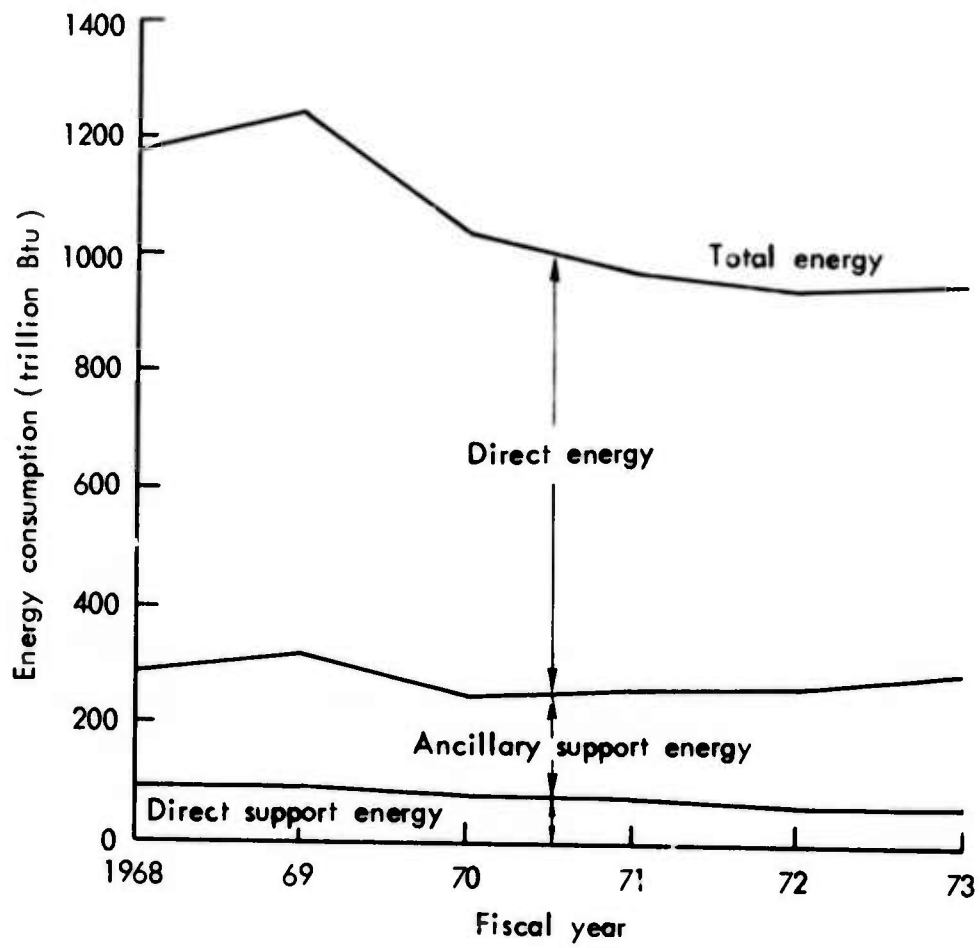
Fig.3 — Historical consumption of energy by USAF
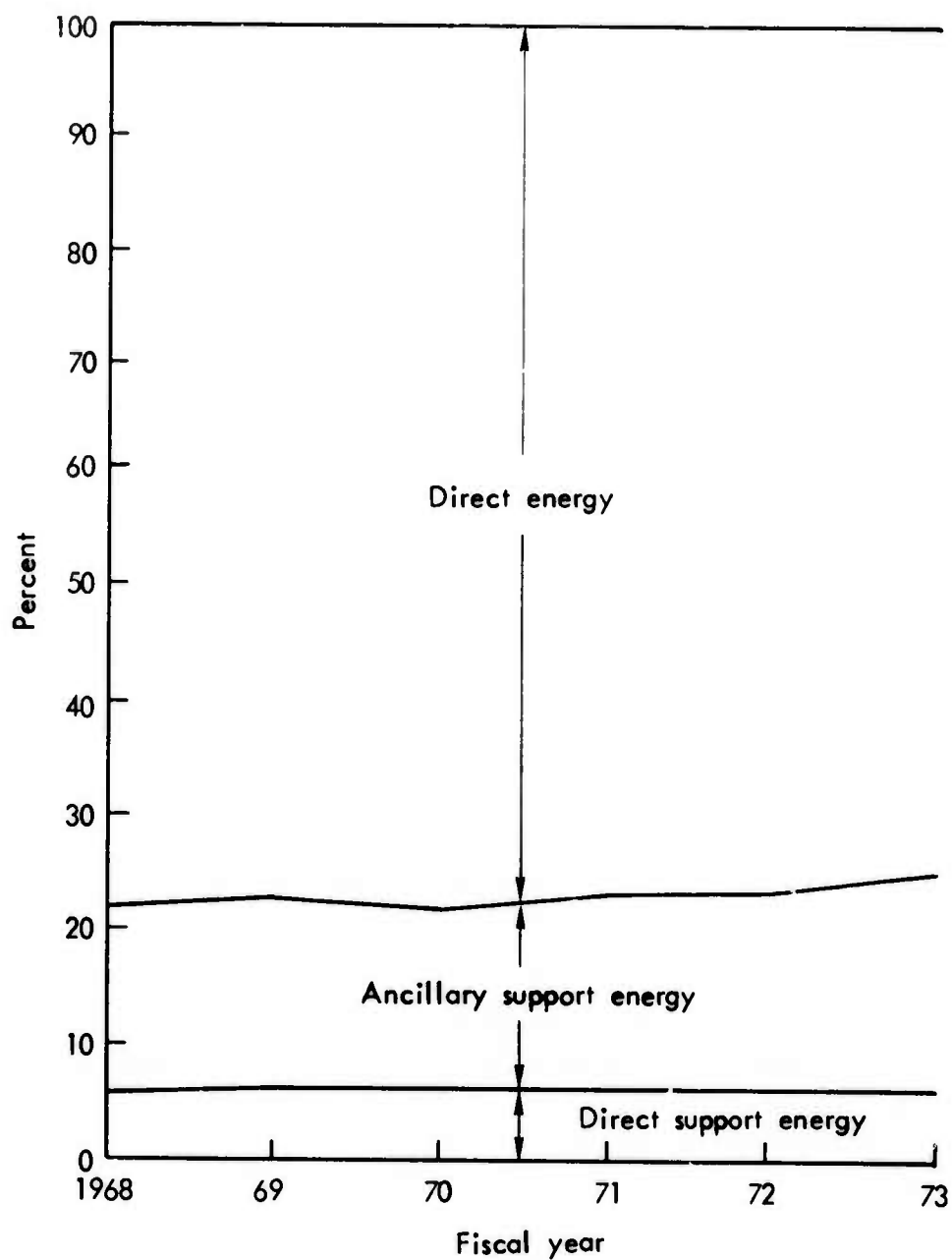
Fig.4 — Historical distribution of energy consumed by USAF
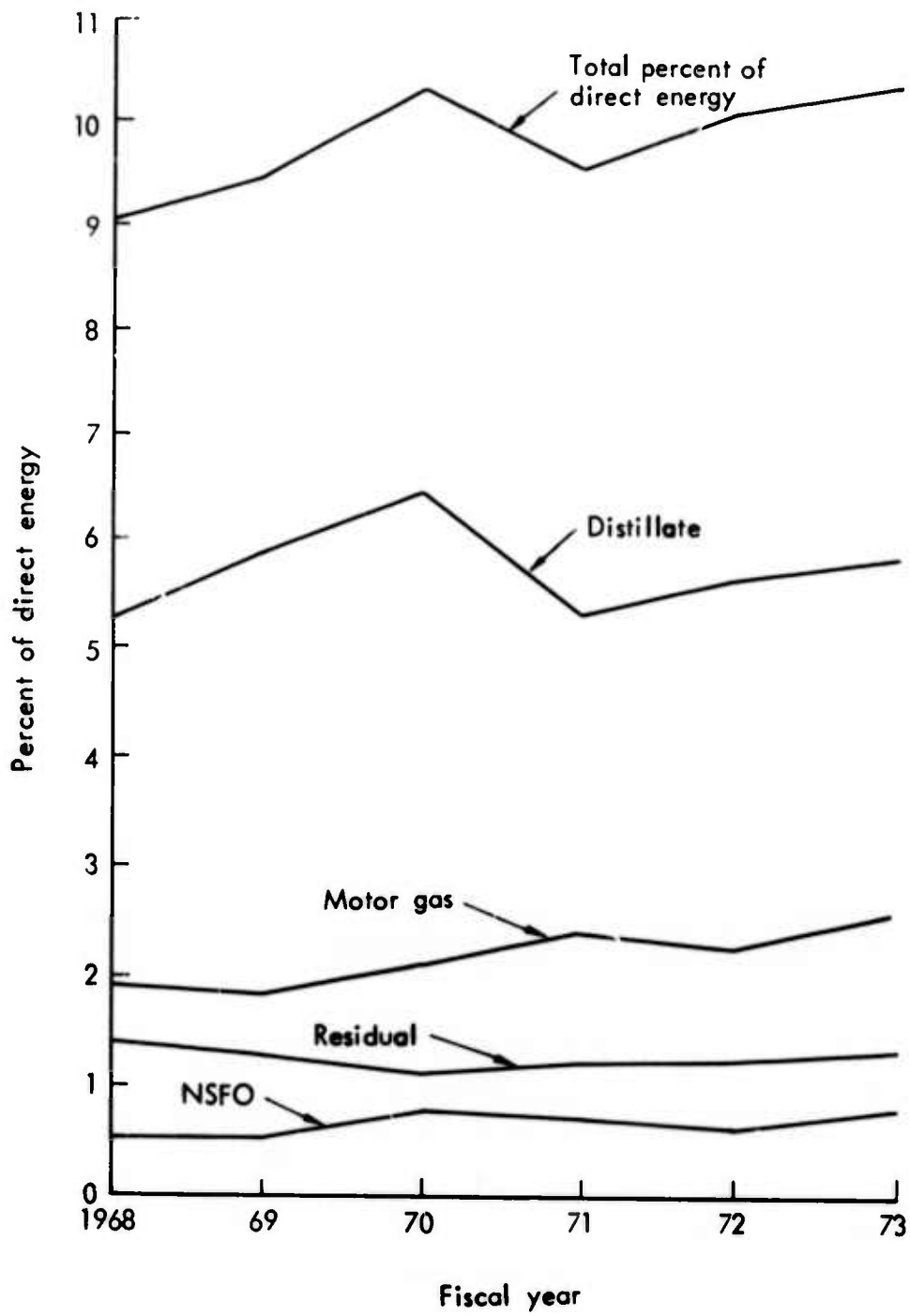
Fig.5 — Historical composition of direct support energy
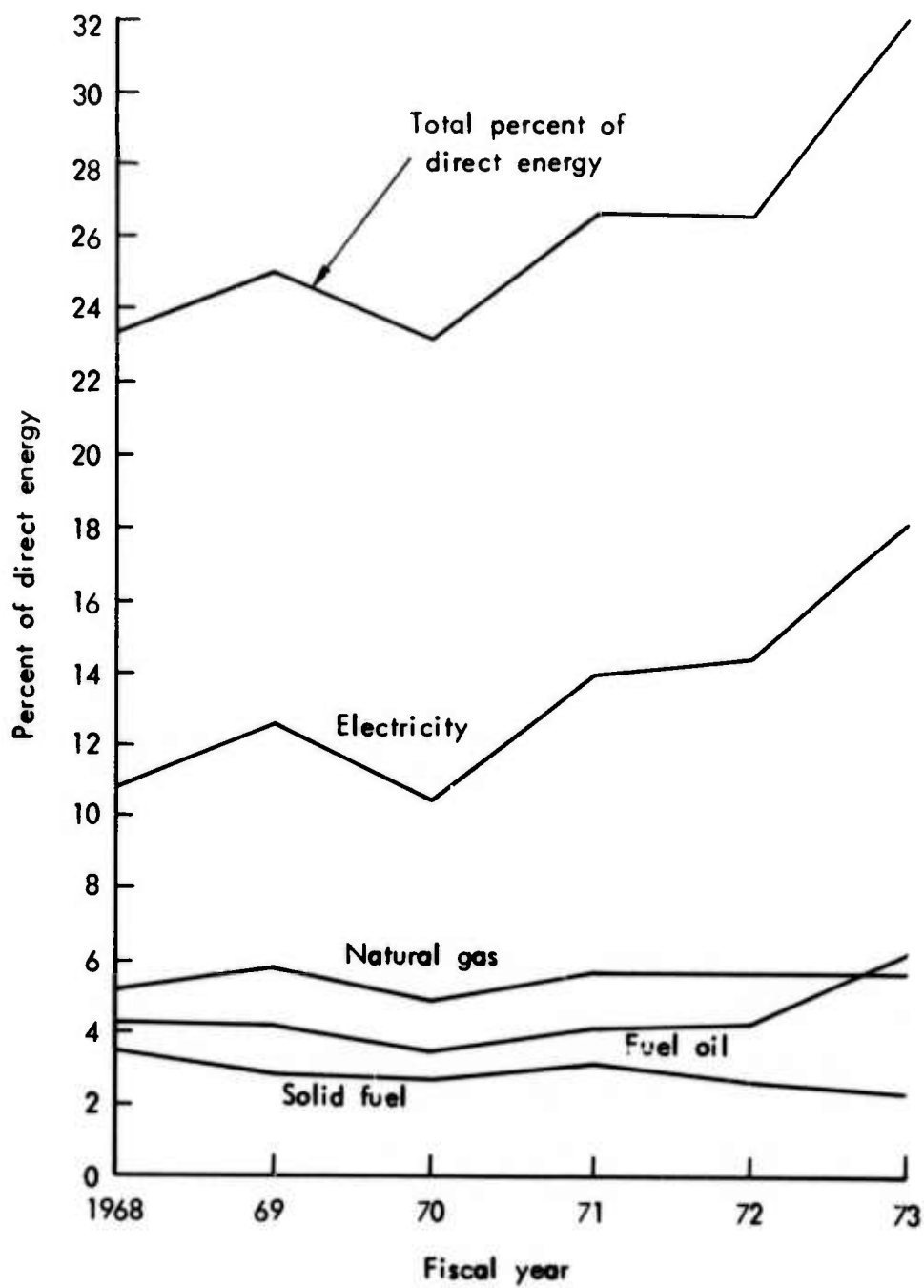
Fig.6 — Historical composition of ancillary support energy

where the information has been plotted as a percentage of the direct
energy. The smooth and steady curves of Fig. 2 are not repeated when
the energy forms are disaggregated. Since the totals are relatively
constant, one might speculate whether fuel substitutions were not par-
tially responsible for the variations of the individual curves. This
possibility exists between distillate and motor gasoline in Fig. 3,
and between electricity and solid fuel (coal) in Fig. 4. There may be
other reasons, such as the increased "creature comforts" that are being
designed into living and working quarters. These comforts, especially
air conditioning, generally require electric power, which could account
for some of the observed increase in the use of electricity.

The discussion thus far has concentrated on the amount of energy
used and the categories and forms of its use. Air Force planners work
in terms of programs, with each program describing a functional activ-
ity of the force. At present there are ten Air Force programs; the
distribution of energy consumption among them is as shown in Table 1.
Three programs accounted for almost 80 percent of the energy consump-
tion in 1972, and five programs accounted for almost 94 percent. The
remaining five programs (III, VI, VII, IX, and X) accounted for only
6.1 percent. An examination of these large differences not unexpectedly
reveals that they are due to flying activity. Strategic, general pur-
pose, and airlift and sealift forces are all heavily oriented toward
aircraft, the heavy users of energy.

To examine further the relationship between flying activity and
energy use, Table 2 was prepared to disaggregate the total USAF flying
hours by program. We have already seen that Programs I, II, and IV
consumed almost 80 percent of the energy; however, the information in
Table 2 shows that these programs accounted for only about 50 percent
of the flying hours. Even more striking is the fact that while Program
IV had 8.4 percent of the flying hours, it used 20.1 percent of the
energy; also, the four "other programs" which used 6.1 percent of the
energy had 22.4 percent of the flying hours. These large differences
are due to the types of aircraft which are being flown, and the dis-
parities between the fraction of flying hours and fraction of energy
consumed only underscore the inadequacy of simply relating these frac-
tions without further clarification.

Table 1

USAF ENERGY CONSUMPTION BY PROGRAM: 1972

Program		Percent of Total	Cumu- lative
I.	Strategic forces	31.3	31.3
II.	General purpose forces	27.0	58.3
IV.	Airlift and sealift forces	20.1	78.4
V.	Guard and reserve forces	9.0	87.4
VIII.	Training, medical, and other general personnel activity	6.5	93.9
	All other programs	6.1	100.0
	Total	100.0	

Table 2

USAF FLYING HOURS BY PROGRAM: 1972

Program		Percent of Total	Cumu- lative
I.	Strategic forces	13.2	13.2
II.	General purpose forces	28.1	41.3
III.	Intelligence and communications	5.0	46.3
IV.	Airlift and sealift forces	8.4	54.7
V.	Guard and reserve forces	10.1	64.8
VI.	Research and development	1.0	65.8
VII.	Central supply and maintenance	0.6	66.4
VIII.	Training, medical, and other general personnel activity	17.8	84.2
IX.	Administration and assoc. activities	1.5	85.7
X.	Support of other nations	14.3	100.0
	Total	100.0	

Table 3 disaggregates these data by aircraft type rather than program, thus giving a somewhat different perspective. We see that the single largest user of aircraft fuel is cargo/transport aircraft, at 32.6 percent of the total, in contrast to 20.1 percent of the total for Program IV, airlift and sealift forces. From this we can conclude that the single largest aircraft energy-consuming function is the transport of people and materiel, but that only about two-thirds of this transport is conducted under Program IV. The balance of the transport function is distributed among the other programs, and is mainly in the general purpose forces (Program II).

Table 4 lists the energy consumption by aircraft, and identifies not only which aircraft are the largest users of energy, but also indicates that a fairly small number of aircraft consume most of the energy. This fact is of extreme importance in analyzing the use of energy by aircraft, and eases the task of the planner, as we shall see later.

Tables 3 and 4 consider only the direct use of energy. The energy used for direct support and ancillary support cannot be apportioned in the same fashion to programs, types of aircraft, or individual aircraft. Part of the reason for this is that the data are simply too aggregated to allow such an apportionment. In addition, attempting to apportion the heating and lighting energy used on bases to programs or aircraft is very complex, and even if it could be estimated, the results would not be particularly useful in the context of understanding energy use in the Air Force.

Table 3

ENERGY CONSUMPTION BY TYPE OF AIRCRAFT: 1972
(Programmed)

Type	Trillion Btu	Million Barrels	Percent	Cumulative Percent
Attack	9.75	1.91	1.5	1.5
Bomber/recon	122.71	24.13	19.0	20.5
Tanker	82.13	16.13	12.7	33.2
Fighter/recon	157.95	30.99	24.4	57.6
Cargo/transport	211.00	41.40	32.6	90.2
Helicopter	5.68	1.14	0.9	91.1
Trainer	56.60	11.05	8.7	99.8
Miscellaneous	1.57	0.25	0.2	100.0
Total	647.39	127.00	100.0	

Table 4

ENERGY CONSUMPTION BY SPECIFIC AIRCRAFT: 1972
(Programmed)

Aircraft	Trillion Btu	Million Barrels	Percent	Cumulative Percent
C-141	114.19	22.40	17.64	17.64
B-52	94.82	18.61	14.65	32.29
F-4	94.30	18.61	14.57	46.86
KC-135	76.13	14.94	11.76	58.62
C-130	48.51	9.51	7.49	66.11
T-38	27.49	5.40	4.25	70.36
C-5A	16.77	3.29	2.59	72.95
EC/RC-135	14.14	2.77	2.18	75.13
F-111	13.38	2.63	2.07	77.20
All others	147.66	28.84	22.80	100.00
Total	647.39	127.00	100.00	

III. FRAMEWORK AND OPERATION OF THE USAF ENERGY MODEL

The type of information discussed in Sec. II forms the basis for constructing a USAF energy projection model. The objectives of the model are to translate force posture information[7] into energy requirements and to provide a tool for easily and quickly analyzing the effects of force changes on energy requirements. This model, part of a DoD energy model, is designed to estimate the Air Force portion of DoD energy consumption under a wide variety of conditions chosen by the analyst. The model is designed for use by force planners and others who traditionally work with the size, composition, and activity of the USAF. It uses input information structured in terms familiar to force planners; that is, inputs and outputs are related to programs insofar as this is desirable and practical. An idealized and simplified diagram of the model's function is shown in Fig. 7. The inputs themselves are described in terms of aircraft and ICBMs. The model operates on a yearly basis, and the analyst may select any number of years up to ten for examination. This feature allows the force to be changed over time as desired, with old weapon systems phasing down, or out, and new systems building strength as they are introduced and become operational. To augment this capability and to extend the model's flexibility to analyze the energy needs of future forces, energy effects of hypothetical as well as current systems may be estimated. Thus the analyst may estimate the annual energy requirements of a USAF that introduces B-X, F-X, C-X, or other aircraft in the future.

Weapon system activity rates, such as aircraft flying hours, may also be varied at will, again providing the analyst with the ability to test the effect upon energy requirements of varying this key parameter. Technological improvements, such as engine modifications, engine retrofit, and improved aerodynamics, are reflected in fuel consumption rate inputs to the model.

In addition to calculating the direct energy requirements for the prime mission equipment, the model estimates the direct support and ancillary support energy requirements and sums them for yearly totals.

INPUTS   OUTPUTS

| YEAR N |
| YEAR 2 |

USAF FORCE STRUCTURE YEAR 1

PROGRAM I – STRATEGIC FORCES

Weapon System	Activity Rate
B-52	
Minuteman	
etc.	

PROGRAM II – GENERAL PURPOSE FORCES

Weapon System	Activity Rate

ETC.

MODEL

| YEAR N |
| YEAR 2 |

USAF ENERGY CONSUMPTION YEAR 1

PROGRAM I – STRATEGIC FORCES

Fuel Type	Amount
Jet Fuel	
etc.	

PROGRAM II – GENERAL PURPOSE FORCES

Fuel Type	Amount

ETC.
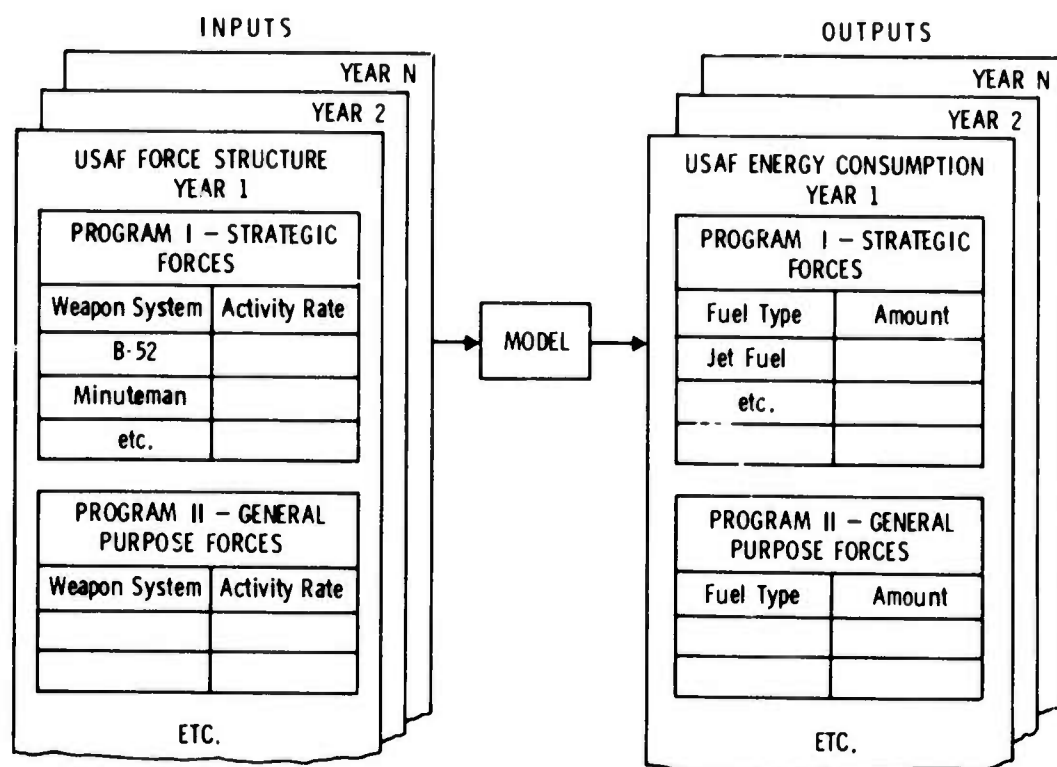
Fig.7 — User's view of USAF energy model

These totals, while strictly estimates, are expected to be very close
to the actual values which have been historically observed if the his-
torical inputs are used. The outputs are in terms of Btu, so that the
various forms of energy may be combined in this common unit of measure.
They also appear disaggregated by form of energy, displayed in commonly
used physical units (gallons, tons, kWh, etc.), so that the analyst may
see how much of each energy form is estimated. A table of factors for
converting from energy units to physical units is given in Appendix A.

Figure 8 is an aggregate flow diagram of the USAF energy model,
depicting its major elements and the sequence of execution. The model
is separated into two major subsections, which are programmed to per-
form the necessary calculations to estimate the total direct energy
consumed by the PME and the direct and ancillary energy consumed in
support of the PME. The first subsection deals with direct energy
consumption by weapon systems (W/S in the figure) such as aircraft and
ICBMs. The second subsection deals with direct support and ancillary

INPUT PROGRAM INFORMATION → ESTIMATE DIRECT ENERGY REQUIREMENTS FOR W/S FOR PROGRAM I → REPEAT ESTIMATING CALCULATION FOR EACH YEAR DESIRED → Ⓐ

Ⓐ → SUM W/S ENERGY REQUIREMENTS OVER NO. OF YRS ANALYZED → REPEAT FOR REMAINING W/S IN PROGRAM → SUM PROGRAM ENERGY REQUIREMENTS FOR EACH YR ANALYZED → REPEAT FOR REMAINING PROGRAMS AND W/S → Ⓑ

Ⓑ → SUM ALL DIRECT ENERGY REQUIREMENTS FOR EACH YR ANALYZED → ESTIMATE DIRECT SUPPORT ENERGY REQUIREMENTS → ESTIMATE ANCILLARY SUPPORT ENERGY REQUIREMENTS → Ⓒ

Ⓒ → SUM TOTAL ENERGY REQUIREMENTS BY ENERGY TYPE → CONVERT ENERGY TO OUTPUT UNITS DESIRED → PRINT OUTPUT

Fig.8 — Simplified model structure

support energy consumption based on the results from the first subsection.

Three alternative methods are provided to estimate direct energy requirements for aircraft so that both existing and hypothetical aircraft may be treated in the model. Thus, for analytical purposes, a force may be examined which begins as a programmed force of existing aircraft, but as time goes by, gradually phases in new aircraft which may be completely hypothetical. For the known aircraft, actual fuel consumption rate factors are used;[8] for the hypothetical aircraft, two options are available. The first option is to assume a consumption rate factor for the aircraft of interest. The second option is to compute (within the model) a fuel consumption rate using an energy estimating relationship (EER) based on certain aircraft characteristics such as weight and speed. This feature allows the analyst to examine the energy requirements of a changing force while imparting to the process the historical certainty of the fuel consumption of existing

aircraft and the flexibility to examine the effects of hypothetical air-
craft by using EERs.

The type of EERs to be used are the choice of the analyst, who may
have access to a reasonable selection of them. For the purpose of dem-
onstrating the use of the model, we developed a set of simple EERs by
relating the fuel consumption to the weight and speed of the aircraft
by multiple regression techniques. An example for fighter/recon air-
craft appears in Table 5, together with a comparison of the actual data
to the results obtained when using the EER.[*]

The method used to compute ICBM energy consumption roughly paral-
lels the estimating procedure for aircraft. The direct energy require-
ment for missiles is estimated as a function of the number of missiles
in the force. Direct energy consists of that required for missile en-
vironmental control and the operation of those missile systems which are
kept active, both in the missile itself and in the launch control cen-
ters. The estimates are based upon data from existing systems.[+]

After the computations have been completed in the first subsection
for each weapon system, the direct energy for each year is summed. This
sum is then used as the basis to compute the energy requirements for
direct support and ancillary support of the PME.

Other program elements are less susceptible to treatment by the
same type of estimating technique because they are not consumers of
energy in the same way that aircraft or missiles are. Communication
and electronic (C&E) systems, for example, are not fueled in the same
sense that aircraft and missiles are. Because of this, and because
these systems are not subject to changes in force size or activity in
the same way as aircraft and missile systems, they have been included
as part of the ancillary support energy requirements. Their energy
source is largely electricity, which appears under ancillary support
and for which data do not exist which would allow identification of
the amounts required for the C&E systems.

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[*]Additional EERs appear in Appendix C.

[+]Personal communication from Frank N. Bousha, Deputy Director,
Missile Facilities, DCS/Civil Engineering, Department of the Air Force,
regarding Minuteman electricity and diesel fuel consumption factors.

Table 5

FUEL CONSUMPTION RATES--ACTUAL AND COMPUTED[a]

Aircraft	Speed (kn)	Weight (lb)	Actual F.C. (gal/hr)	Computed F.C. (gal/hr)
F-4	1221	49,311	1400	1320
F-5(A)	565	13,663	560	539
F-84(D)	481	16,827	600	606
F-86(A)	522	15,876	580	589
F-89	489	36,824	1140	1004
F-100(C)	713	32,536	1000	961
F-100(D)	775	38,048	950	1071
F-101	873	48,000	1250	1257
F-102(A)	557	28,150	735	856
F-104	1145	22,145	825	785
F-105(B-20)	750	46,998	1400	1223
F-106(A)	1136	34,239	1020	1037
F-111	1196	92,655	1875	1975

[a]Fighter/recon F.C. $= 0.657 \, V^{0.094} W^{0.642}$

$$(R^2 = 0.951, \, SE = 99.7)$$

where F.C. = fuel consumption rate (gal/hr)
   V = cruise speed (kn)
   W = gross weight (lb)
   R^2 = multiple correlation coefficient
   SE = standard error of estimate

While this results in a model in which the level of detail of the estimating process is greater for aircraft than it is for C&E systems, the utility of the model is not impaired. As mentioned above, C&E systems tend to be less subject to changes in force planning than aircraft, for example, and many, such as BUIC, NORAD, and 465L, are of such character than neither their size nor their activity rate will be likely to change. On the other hand, the type, number, and activity of aircraft are subject to frequent change.

The model is built so that its operation is easy for analysts who are perhaps more familiar working with force structures than with computer models. The main inputs consist of force structure information describing the size, composition, and activity of the force for each year to be analyzed. In addition, the energy intensiveness or energy consumption factor (i.e., gal/hr) for each of the energy consuming program elements is required. In the case of aircraft, this means that the inputs include the type of aircraft (such as B-52G), the number of them in the force, the fuel consumption factor, and either the annual flying hours per aircraft or the total flying hours for that type of aircraft. This information is supplied for each year, so that changes in the force size, composition, or activity rate can be expressed. This type of information is regularly used in force planning and force costing exercises, and thus should present no problems to those using this energy model. Once the input information is listed, it is key-punched and the punched cards submitted to the computer together with the deck of program cards. Running time on the computer is very short, and the results are printed in a format that identifies the quantity of energy required for each program element, together with the direct and ancillary support energy requirements and the yearly totals. This format permits the analyst to quickly identify major users of energy, so that, if he desires to change the amount of energy used, he will know where the greatest leverage exists. Printing of the computer output on a year-by-year basis facilitates plotting the results and visualizing temporal energy trends that result from specific time-phased actions in the force. Thus, it is possible to see the effect on energy requirements of introducing new weapon systems into the force, building

their numbers, and increasing their activity rate. The projected energy
needs may then be compared with the projected availability of energy.
If conflicts are found, the sensitivity of energy needs to the force
size, composition, and activity may be tested, and adjustments made ac-
cordingly.

IV.   EXAMPLE OF MODEL USE

In Sec. II, the use of energy by the Air Force in the early 1970s
was shown to be about 1000 trillion Btu per year.   As a part of this
study, energy requirements in the near-term future were estimated by
using the model developed here, with detailed input data from the USAF
Force and Financial Program (F&FP) for fiscal years 1974 through 1978.[7]
The major aircraft and their programs are illustrated in Table 6.   In
addition to the force size and activity rates in the F&FP, fuel consump-
tion factors from AFM 173-10 were used.[8]   The results of these esti-
mates appear in Fig. 9*   It is apparent that energy demand is almost
constant throughout this period.   This may be due to several possible
reasons.   Force posture changes are relatively slow, and the phasing
in and out of aircraft requires several years.   Also, flying hours re-
quired for proficiency and training tend to remain relatively constant
in order to maintain an acceptable level of readiness.

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*Note that the programmed direct energy consumption is about 625
trillion Btu for 1974.   If one were to extrapolate the data for actual
direct energy consumption shown in Fig. 1, the value would be about
640 trillion Btu.   This difference of about 2.4 percent could be due
to an increase in actual flying hours, larger fuel consumption rates,
or both.

It is also interesting to note that this model could be used to
test the validity of past experience in planning for future energy
needs.   Typically the F&FP is revised yearly, with each issue contain-
ing projected flying hours for USAF aircraft for the next 5 or 6 years.
Also, fuel consumption factors (AFM 173-10) change periodically based
on USAF experience.   One would expect the near-term (1 to 2 year) pro-
jections to be more accurate than the far-term (5 to 6 year) projec-
tions.   By using the flying hour data contained in past (5 to 10 year)
issues of the F&FP along with the corresponding fuel consumption fac-
tors, the model could be used to generate the programmed energy consump-
tion for each year over a 5 or 6 year period.   These results could then
be compared to actual energy consumed as reported to DFSC.   It might
then be possible to determine the error in projected energy consumption
as a function of the number of years in the future for which the pro-
jection was made.   Such a comparison was made for a one-year projection
for FY 1971 and FY 1972.   The results show that the actual consumption
differed from the projected consumption by less than one percent in
FY 1971 and by over seven percent in FY 1972.

Table 6

MAJOR ENERGY-CONSUMING USAF AIRCRAFT: FY 1974-FY 1978

Aircraft	I	II	IV	V	VIII	III,VI,VII,IX,X
C-141			X			X
B-52	X					X
F-4/RF-4		X		X		X
KC-135	X	X	X			X
C-130		X	X	X		X
T-38	X	X			X	X
C-5A			X			
EC/RC-135	X	X				X
F-111		X				X
T-37					X	X
F-106	X			X		X
F-100D/F				X		X
F-101	X			X		
F-105		X		X		X
T-33	X	X		X	X	X
FB-111	X					X
T-39	X	X	X	X	X	X
C-124		X		X		
C-135						X
T-29	X	X	X	X	X	X
A-37				X		X
F/TF-102				X		
A-7		X		X		X
C/VC-123		X		X		X
B-57	X	X		X		X
F-100A/C						
C-118	X	X	X	X	X	X
B-66		X				X
KC-97				X		X
C-9		X	X			
F-15A		X				X
A-9/A-10		X				
E-3A	X	X				
UH-1	X	X	X	X	X	X
F-5		X				X
T-43					X	
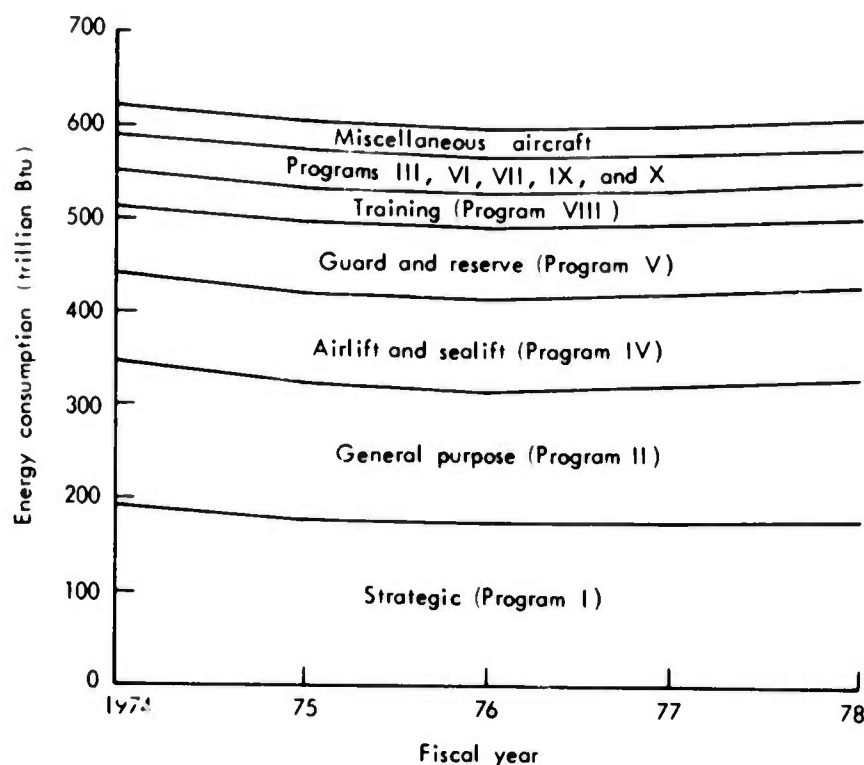
Fig.9 — USAF aircraft programmed energy consumption
FY 1974 - FY 1978

Given the relatively constant level of projected energy consumption,
one might question what kinds of changes might have an effect upon en-
ergy consumption. To show how the model can be used to examine this
question, we have chosen an example for the purposes of illustration
only. In this example, we propose to reduce the size of the B-52 bom-
ber fleet by phasing out all nonnuclear B-52s between 1975 and 1978,
and reduce the KC-135 tanker fleet proportionately. The change that
the planner sees is that the B-52D/F fleet is reduced from its currently
programmed size to zero in three years, and that the number of KC-135
tankers that are required for support of the B-52D/F aircraft are also
phased out. This reduces the flying hours in Program I, thus reducing
the direct energy requirements and the corresponding support energy re-
quirements.

The results of this exercise are illustrated in Fig. 10, along
with pertinent comparative information from Fig. 9. As might be
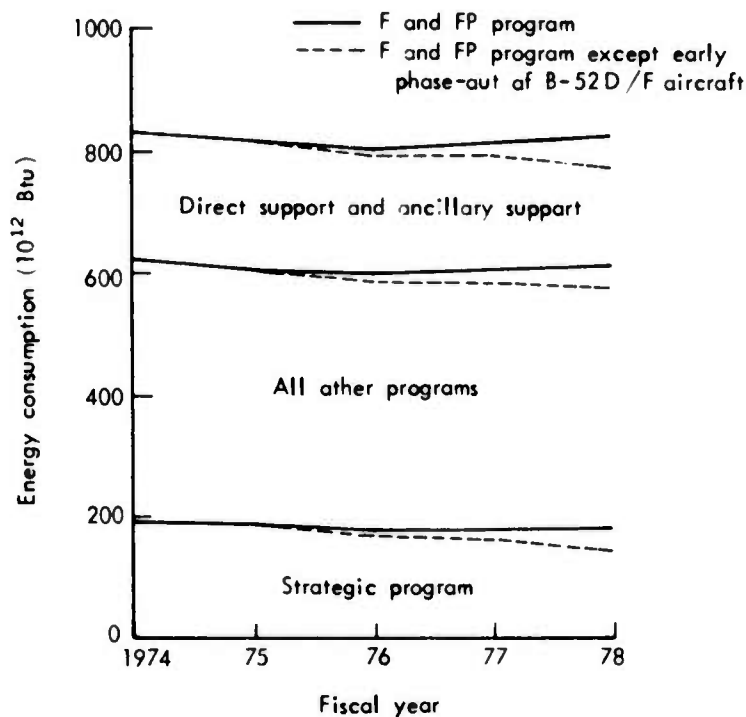
Fig. 10 — Change in energy requirements resulting
from B-52D/F phase-out

expected, this force change produces a relatively small change in total
Air Force energy consumption. As was shown in Sec. II, Program I con-
sumes about 31 percent of the total direct energy, and the B-52D/F fleet
represents only a small proportion of the Program I consumption. Thus
the total USAF energy consumption is reduced by only about 5.5 percent
in 1978. This is a fairly small percentage; however, it represents
about 34 trillion Btu in programmed energy consumption in 1978.

Several lessons can be drawn from this exercise. The first is
that attempts to make sizable changes in Air Force energy use must be
directed towards those areas where a great deal of energy is used. The
areas with the most potential appear to be Programs I, II, IV, and V
(see Fig. 9). Ancillary support energy would also appear to have po-
tential, but its nature makes it less susceptible to analysis regarding
energy conservation. Much of the energy consumed in ancillary support
is for creature comforts, such as heating, lighting, hot water, etc.,
and while changes in the amounts of such energy consumed per person are

certainly possible, they cannot be analyzed with this model because the model is designed to use programming information concerning the PME as inputs and because support energy is estimated as a function of direct energy. As a result, the model will only show changes in support energy due to changes in direct energy, and not changes in support energy that result from structural changes in the use of energy for support.

The second lesson is that desired substantive changes are difficult to realize by making changes that are relatively cosmetic. The data in Table 4 show that six aircraft consume about 70 percent of the direct energy in the Air Force, and that the next largest consuming aircraft uses less than 3 percent. Thus, if a reduction of more than 3 percent in energy use is desired, the planner is faced with the choice of altering the flying activity of either a few of the top six aircraft or many of the remaining aircraft. This is demonstrated quite clearly in the B-52D/F exercise used here as an example.

To carry this further, program changes which result in the substitution of nonflying activities for flying activities should lessen Air Force energy consumption, particularly if any of the "big six" energy-consuming aircraft are involved. The use of simulators as a replacement for flying would reduce energy use, particularly if they could be used outside of Program VIII and with the C-141, B-52, F-4, or KC-135. The substitution of satellites for reconnaissance aircraft would also save energy, as would the replacement of bombers by ICBMs. These qualitative assessments are easily made. However, in order to quantify the energy changes and to assess their long-term effects, it is necessary to use the model. This is particularly true if changes are made in more than one program and in more than one year.

V.   GUIDE TO USE OF THE MODEL

As previously indicated, the model is designed for use by force planners and others who are concerned with projections of force size, composition, and activity rates for the Air Force. A description and listing of the FORTRAN IV computer program are given in Appendix A. In this section, a hypothetical example is given illustrating the use of the model. Inputs required for the model are described, followed by illustration of the output of the model. A complete set of data used to produce the output results for the hypothetical example is appended to the FORTRAN IV program listing in Appendix A.

MODEL INPUTS

The data cards (exclusive of job control cards) for the input deck are:

Card 1: Run title (72 columns)

Card 2: Base year (4 columns)

Card 3: Program name (72 columns)

Card 4: Program element name (12 columns)

Program element data cards

End designator cards (3 columns)

Each program element data card contains six data entries. Each entry on the data card is identified by an index number ranging from 001 to 079. The number of program element data cards is dependent on the number of program elements to be analyzed. It is open-ended in the sense that the number of program elements that are entered is unlimited (within the bounds of practicality).

There are four end designator cards. They signal (1) the end of a program element, (2) the end of a program containing one or more program elements, (3) the end of a run, and (4) the end of the session, indicating all input data have been processed.

The definition of each of the indexes used in the model is given in Table 7 and two samples of input data are shown in Figs. 11 and 12. Each input sheet contains exactly the same data. Both illustrate that the order in which the data are entered is immaterial. The index is coded in the first three columns followed by the data value for that index in the next eight columns. Each field of data is separated by one column space. If a data value repeats itself for several consecutive indexes, it need not be entered for each index. A value of (-1) may be used as the data entry value for the first index of repetition and the model repeats the initial value for the remaining indexes. A value of (-2) as the data entry value tells the model that this is the last index of repetition. The (-2) may be omitted if the data values are repeated for the remaining indexes in the category. Examples of this procedure are shown in Figs. 11 and 12. If an index and data value are not provided for a program element, the model uses the last read value associated with the index, or 0 if none has been read.

Most of the index definitions given in Table 7 are self-explanatory; however, the following comments may be helpful.

Index	Comment
001-060	These are divided into six sets of 10 each with the first and last number in each set corresponding to the first and last year being analyzed.
062	Whenever the fuel type is changed, a corresponding change must be made for index 063.
063	See 062.
064-066	These are values for the coefficients in the equation for calculating fuel consumption rate. They may also be used for other similar equations having three or less coefficients.
069	The value entered here is unity if all program elements that contribute to direct energy consumption are included in the analysis. However, as we have seen, a few program elements are major energy consumers and account for the bulk of the energy used. There are also

Table 7

USAF ENERGY CONSUMPTION MODEL INPUT INDEXES

Index	Description
001-010	Aircraft unit equipment (UE) or missile UE
011-020	Type of flying hour input (1 = flying hour per UE, 2 = total flying hours)
021-030	Flying hours per UE or total flying hours for each type UE
031-040	Fuel consumption rate per flying hour
041-050	Speed of hypothetical aircraft[a]
051-060	Weight of hypothetical aircraft[a]
061	Identification of program element type (1 = real aircraft, 2 = hypothetical aircraft, estimated fuel consumption rate, 3 = hypothetical aircraft, calculated fuel consumption rate, 4 = missile)
062	Type of fuel for aircraft (1 = jet fuel, 2 = other type fuel)
063	Conversion factor--gallons to Btu
064, 065, 066	Coefficients for hypothetical aircraft fuel consumption rate equation [e.g., F.C. = $F(064)*speed**F(065)*weight**F(066)$]
067	Clear designator (0 = do not clear, 1 = clear all data)
068	Input dump designator (0 = do not print input dump, 1 = print input dump)
069	Direct energy modification factor, Total Direct Energy/F(069)
070	Electricity consumption factor for missiles (350,000 kWh per missile per year)
071	Diesel fuel consumption factor for missiles (1165 gal per missile per year)
072	Consumption factor for motor gasoline, %, direct support
073	Consumption factor for distillate fuel, %, direct support
074	Consumption factor for residual fuel, %, direct support
075	Consumption factor for Navy special fuel, %, direct
076	Consumption factor for electricity, %, ancillary support
077	Consumption factor for diesel fuel, %, ancillary support
078	Consumption factor for coal, %, ancillary support
079	Consumption factor for natural gas, %, ancillary support

End Designators:

    666 = end of program element
    777 = end of program
    888 = end of run
    999 = end of session

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[a]Used to calculate fuel consumption rate when rate is not estimated.

AIR FORCE ENERGY CONSUMPTION MODEL

INPUT SHEET

Analyst _____ Dept. _____ Job No. _____ Project No. _____ Date _____

Index	Field 1		Field 2		Field 3		Field 4		Field 5		Field 6
	Value	Index	Value	Index	Value	Index	Value	Index	Value	Index	Value
	TEST RUN NO. 1										
	1972										
	STRATEGIC PROGRAM 1										
	B-99										
001	400.002	-1.005	-1.005	-2.006	-2.006	350.007	340.008	340.008	330		330
007	320.010	310.011	310.011	2.012	2.012	-1.014	-2.015	-2.015	1		1
016	-1.021	400.060.022	400.060	390.060.023	390.060	390.060.024	370.000.025	370.000	900		900
026	1.000.027	-1.031	-1	3.500.032	3.500	-1.061	1.062	1			1
063	12.300.072	2.11.073	2.11	5.71.074	5.71	1.23.075	1.61.076	1.61	13.11		13.11
077	4.26.078	2.81.079	2.81	5.37							
666											
010-111											
001	990.002	580.003	580	920.224	920	960.005	950.006	950	940		940
007	930.008	920.009	920	920.010	920	900.061	4.070	4	350.000		350.000
071	1.165										
777											
	GENERAL PLEASE PROGRAM 1										
	E-79										
	etc.										
999											

Fig. 11 — Sample input data

AIR FORCE ENERGY CONSUMPTION MODEL

INPUT SHEET

Analyst _____ Dept. _____ Job No. _____ Project No. _____ Date _____

Index	Field 1 Value	Index	Field 2 Value	Index	Field 3 Value	Index	Field 4 Value	Index	Field 5 Value	Index	Field 6 Value
TEST RUN NO. 1											
197-2											
STRATEGIC PROGRAM 1											
6-99											
661	1.072	023	2.11	079	5.71	075	1.63	076	.61		13.12
677	4.26 071	079	2.91	062	5.37	062	1	062	117.000		
OC1	400.002	025	-1	006	-2	007	350	008	345		330
009	320.010	021	310.000	022	330.000	023	340.000	024	380.000		370.000
025	900.026	027	1.200	011	-1	012	2	014	-1		-2
015	-1 016	031	-1	022	3.200		-1				
666											
CC-III											
061	4 070	071	350.000	201	1165		990	022	98.	023	970
004	960.025	006	950.000	007	940		936		920	009	910
010	900										
777											
GENERAL PURPOSE PROGRAM 2											
E-79											
(etc.)											
999											

Fig. 12 — Sample input data

Index	Comment

Index   Comment

a large number of program elements that individually use very little energy. For example, if there were a total of 65 program elements and 25 of them consumed an estimated 95 percent of the direct energy, a value of 0.95 would be entered. This adjusts the model output for the remaining 5 percent of the direct energy consumed by the other 40 program elements and greatly reduces the quantity of input data required in order to make reasonable estimates.

070-071   These are direct inputs to the model based on the average yearly requirements for each missile.

072-079   Input values are entered as a percent of direct energy use.

MODEL OUTPUT

An illustration of energy consumption for program elements in a strategic program, general purpose program, and an airlift and sealift program, is shown in Table 8. The output shown includes an aircraft and an intercontinental ballistic missile of current design, designated the B-99 and CC-III, respectively, and two hypothetical aircraft designated the LB-1 and LB-2. (Designations used in Table 8 are fictitious and are given to demonstrate the model.) The fuel consumption rate for the LB-1 is specified by the analyst as input values (indexes 031-040). The fuel consumption rate for the LB-2 is computed by the model based on inputs of speed (041-050), weight (051-060), and EER coefficients (064, 065, 066).

Subtotals of energy consumption by each program are given, followed by the total direct energy consumption for all three programs. Following the output data for direct energy are tables of direct support and ancillary support energy consumption. The direct support energy tables give the energy consumption by type: motor gasoline, distillate fuel, residual fuel, and Navy special fuel oil. The ancillary support energy table also gives energy consumption by type: electricity, natural gas, fuel oil, and coal.

Table 8

COMPUTER MODEL OUTPUT

STRATEGIC PROGRAM I

CONSUMPTION RATES

(GAL IN MILLIONS, KWH IN BILLIONS, BTU'S IN TRILLIONS)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	TOTAL
B-99											
GAL-JET	1399.999	1354.999	1322.999	1294.999	1259.999	1224.999	1189.999	1154.999	1119.999	1084.999	12424.973
BTU	166.600	162.435	158.270	154.105	149.940	145.775	141.610	137.445	133.280	129.115	1478.572
UF	400	400	400	400	400	350	340	330	320	310	
FH	500000	490000	380000	370000	900	1000	1000	1000	1000	1000	
B-78											
GAL-JET	899.999	963.999	828.000	792.000	756.000	719.999	681.999	647.999	611.999	575.999	7379.977
BTU	107.100	102.916	98.532	94.248	89.964	45.680	81.396	77.112	72.828	68.544	878.218
UF	500	480	400	440	420	400	380	360	340	320	
FH	500000	480000	400000	440000	420000	1000	1000	1000	1000	1000	
LB-1											
GAL-OTH	222.000	222.000	222.000	222.000	222.000	222.000	222.000	222.000	222.000	222.000	2219.998
BTU	105.672	105.672	105.672	105.672	105.672	105.672	105.672	105.672	105.672	105.672	1056.717

INPUT DUMP

90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00
2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
185000.00	185000.00	185000.00	185000.00	185000.00	185000.00	185000.00	185000.00	185000.00	185000.00
1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00	1200.00
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.00	2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	2.11	47600.00	1.23	0.61	14.12	6.26	1.00	1.00	0.0
		5.71					2.81	5.37	

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	TOTAL
LB-2											
GAL-JET	624.311	624.311	624.311	624.311	624.311	624.311	624.311	624.311	624.311	624.311	6243.098
BTU	74.293	74.293	74.293	74.293	74.293	74.293	74.293	74.293	74.293	74.293	1056.928

INPUT DUMP

400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
570000.00	570000.00	570000.00	570000.00	570000.00	570000.00	570000.00	570000.00	570000.00	570000.00
1095.28	1095.28	1095.28	1095.28	1095.28	1095.28	1095.28	1095.28	1095.28	1095.28
700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00
40000.00	40000.00	40000.00	40000.00	40000.00	40000.00	40000.00	40000.00	40000.00	40000.00
3.00	1.00	43000.00	3.66	0.09	0.94	0.26	1.00	1.00	0.0
0.0	2.11	2.71	1.23	0.61	13.12		2.81	5.37	0.0

INDEXES	
1-10	
11-20	
21-30	
31-40	
41-50	
51-60	
61-70	
71-80	

TEST RUN NO. 1

CONSUMPTION RATES
(GAL IN MILLIONS, KWH IN BILLIONS, BTU'S IN TRILLIONS)

STRATEGIC PROGRAM I

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	TOTAL
CC-III											
KWH-ELEC	0.346	0.343	0.339	0.336	0.332	0.329	0.325	0.322	0.318	0.315	3.307
GAL-DSL	1.153	1.142	1.130	1.118	1.107	1.095	1.043	1.072	1.060	1.046	11.069
BTU	3.799	3.760	3.722	3.683	3.645	3.607	3.568	3.530	3.492	3.453	16.459
UE	990	980	970	960	950	940	930	920	910	900	
XY-V											
KWH-ELEC	0.175	0.171	0.168	0.164	0.161	0.157	0.154	0.150	0.147	0.143	1.542
GAL-DSL	0.582	0.571	0.559	0.548	0.536	0.524	0.511	0.501	0.489	0.474	5.301
BTU	1.918	1.880	1.842	1.803	1.765	1.727	1.688	1.650	1.612	1.573	17.458
INPUT DUMP											INDEXES
	500.00	490.00	480.00	470.00	460.00	450.00	440.00	430.00	420.00	410.00	1-10
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11-20
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21-30
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31-40
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41-50
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51-60
	4.00	1.00	1.00	0.66	0.09	0.04	0.0	1.06	1.00	350000.00	61-70
	1165.00	2.11	5.71	1.23	0.61	13.12	4.26	2.81	5.37	0.0	71-80
SUBTOTAL											
GAL-JET	2924.309	2453.309	2782.309	2711.309	2640.309	2569.309	2498.309	2427.309	2356.309	2285.309	26043.086
GAL-OTH	222.000	222.000	222.000	222.000	222.000	222.000	222.000	222.000	222.000	222.000	2219.999
KWH-ELEC	0.541	0.514	0.507	0.500	0.493	0.486	0.471	0.472	0.465	0.458	4.900
GAL-DSL	1.736	1.713	1.689	1.666	1.643	1.619	1.596	1.574	1.549	1.526	16.310
BTU	459.361	450.855	442.329	433.804	425.278	416.752	408.226	399.700	391.175	382.649	4210.148

TEST RUN NO. 1

GENERAL PURPOSE PROGRAM II

CONSUMPTION RATES

(GAL IN MILLIONS, KWH IN BILLIONS, BTU'S IN TRILLIONS)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	TOTAL
F-79											
GAL-JET	699.999	763.999	827.999	791.999	755.999	719.999	683.999	647.999	611.999	575.999	7371.373
BTU	107.100	102.416	98.532	94.248	89.964	85.680	81.396	77.112	72.828	68.544	877.217

INPUT DUMP

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	INDEXES
	500.00	440.00	460.00	440.00	420.00	400.00	380.00	360.00	340.00	320.00	1-10
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	11-20
	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	21-30
	1800.00	1800.00	1800.00	1800.00	1800.00	1800.00	1800.00	1800.00	1800.00	1800.00	31-40
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41-50
	1.00	1.00	0.0	0.0	0.09	0.0	0.0	0.0	0.0	0.0	51-60
	1.00	1.00	119000.00	0.66	0.61	0.04	0.0	1.00	1.00	350000.00	61-70
	1165.00	2.11	5.71	1.23		13.12	4.26	2.91	5.37	0.0	71-80

SUBTOTAL

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	TOTAL
GAL-JET	699.999	763.999	827.999	791.999	755.999	719.999	683.999	647.999	611.999	575.999	7371.373
GAL-OTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KWH-ELEC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GAL-DSL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BTU	107.100	102.416	98.532	94.248	89.964	85.680	81.396	77.112	72.828	68.544	877.217

TEST RUN NO. 1   PAGE   4

CONSUMPTION RATES
(GAL IN MILLIONS, KWH IN BILLIONS, BTU'S IN TRILLIONS)

AIRLIFT AND SEALIFT PROGRAM IV

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	TOTAL
C-600											
GAL-JET	1393.999	1364.999	1329.999	1294.999	1259.999	1224.999	1189.999	1154.999	1119.999	1084.999	12424.969
BTU	166.600	162.435	156.270	154.105	149.940	145.775	141.610	137.445	133.280	129.115	1476.572
UF	400	390	380	370	360	350	340	330	320	310	
FH	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	
LB-1											
GAL-OTH	222.000	222.000	222.000	222.000	222.000	222.000	222.000	222.000	222.000	222.000	2219.995
BTU	105.672	105.672	105.672	105.672	105.672	105.672	105.672	105.672	105.672	105.672	1056.717
UF	90	90	90	90	90	90	90	90	90	90	90
FH	185000	185000	185000	185000	185000	185000	185000	185000	185000	185000	
LB-7											
GAL-JET	624.311	624.311	624.311	624.311	624.311	624.311	624.311	624.311	624.311	624.311	6243.060
BTU	74.293	74.293	74.293	74.293	74.293	74.293	74.293	74.293	74.293	74.293	742.924
UF	400	400	400	400	400	400	400	400	400	400	
FH	570000	570000	570000	570000	570000	570000	570000	570000	570000	570000	
SUBTOTAL											
GAL-JET	2024.309	1989.309	1954.309	1919.309	1884.309	1849.309	1814.311	1779.310	1744.310	1709.310	18608.096
GAL-OTH	222.000	222.000	222.000	222.000	222.000	222.000	222.000	222.000	222.000	222.000	2219.998
KWH-ELEC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GAL-DSL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BTU	346.564	342.399	338.234	334.069	329.904	325.739	321.574	317.409	313.244	309.079	3278.218

TOTALS FOR ALL PROGRAMS

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	TOTAL
GAL-JET	5844.613	5706.613	5564.613	5422.613	5280.613	5138.613	4996.613	4854.613	4712.617	4570.617	52096.141
GAL-OTH	444.000	444.000	444.000	444.000	444.000	444.000	444.000	444.000	444.000	444.000	4439.992
KWH-ELEC	0.521	0.514	0.507	0.500	0.493	0.486	0.479	0.472	0.465	0.458	4.900
GAL-DSL	1.736	1.713	1.689	1.666	1.643	1.619	1.596	1.573	1.549	1.526	16.310
BTU	911.044	896.069	879.695	862.121	845.146	828.171	811.196	794.221	777.247	760.272	8360.570

TEST RUN NO. 1

(GAL, TON, IN MILLIONS, KWH, CUFT IN BILLIONS, BTU'S IN TRILLIONS)

	1972	1973	1974	1975	1976	1977	1974	1979	1980	1981	TOTAL
DIRECT SUPPORT											
MOTOR GASOLINE											
GAL	154.122	151.256	148.391	145.526	142.661	139.795	136.930	134.064	131.199	128.334	1412.277
BTU	19.265	18.907	18.549	18.191	17.833	17.474	17.116	16.758	16.400	16.042	176.535
DISTILLATE FUEL											
GAL	375.070	368.097	361.124	354.151	347.178	340.205	333.232	326.259	319.286	312.313	3436.915
BTU	52.135	51.166	50.196	49.227	48.258	47.288	46.319	45.350	44.381	43.411	477.731
RESIDUAL FUEL											
GAL	74.870	73.478	72.086	70.694	69.302	67.910	66.518	65.126	63.734	62.342	686.058
BTU	11.230	11.022	10.813	10.604	10.395	10.186	9.978	9.769	9.560	9.351	122.909
NAVY SPECIAL FUEL OIL											
GAL	37.130	36.440	35.750	35.060	34.369	33.679	32.989	32.299	31.608	30.918	340.240
BTU	5.570	5.466	5.362	5.259	5.155	5.052	4.948	4.845	4.741	4.638	51.036
TOTAL BTU	89.200	86.560	84.920	83.281	81.641	80.001	78.361	76.722	75.082	73.442	838.210
ANCILLARY SUPPORT											
ELECTRICITY											
KWH	10.887	10.682	10.477	10.272	10.067	9.862	9.657	9.451	9.246	9.041	99.642
BTU	114.316	112.162	110.008	107.855	105.701	103.548	101.394	99.241	97.087	94.933	1046.244
FUEL OIL											
GAL	278.049	272.410	267.731	262.552	257.373	252.194	247.015	241.836	236.657	231.478	2547.833
BTU	38.656	37.734	37.415	36.495	35.775	35.055	34.335	33.615	32.895	32.175	354.149
COAL											
TON	1.026	1.007	0.988	0.969	0.950	0.931	0.912	0.893	0.874	0.855	9.404
BTU	25.657	25.180	24.703	24.226	23.749	23.272	22.795	22.318	21.841	21.364	235.101
NATURAL GAS											
CUFT	47.602	46.717	45.832	44.947	44.062	43.177	42.292	41.407	40.522	39.637	430.178
BTU	49.030	48.119	47.207	46.296	45.384	44.473	43.561	42.650	41.738	40.827	449.284
TOTAL BTU	227.657	223.395	219.133	214.871	210.609	206.347	202.085	197.824	193.561	189.299	2084.779

A I R   F O R C E   E N E R G Y   C O N S U M P T I O N   M O D E L

S U M M A R Y   T A B L E

(BTU'S IN TRILLIONS)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	TOTAL
TOTAL DIRECT ENERGY	913.044	896.069	879.095	862.121	845.146	828.171	811.195	794.221	777.247	760.272	8366.570
TOTAL DIRECT SUPPORT ENERGY	89.200	86.560	84.920	83.281	81.641	80.001	78.361	76.722	75.082	73.442	808.210
TOTAL ANCILLARY SUPPORT ENERGY	227.657	223.395	219.133	214.871	210.609	206.347	202.035	197.823	193.561	189.299	2084.779
USAF TOTAL ENERGY CONSUMPTION	1229.901	1206.024	1183.148	1160.272	1137.396	1114.519	1091.642	1068.766	1045.889	1023.013	11259.559

A summary of all energy consumed by the Air Force is given on the final page of Table 8. It shows the yearly and cumulative 10-year totals for the three categories of energy plus the total of all three.

The primary unit of measure used throughout the program is Btu. All direct energy is calculated in this unit of measure by converting gallons of fuel consumed to Btu. Direct support and ancillary support energy consumption are computed as ratios of direct energy consumption. For the convenience of the analyst, output results are given in both energy units and physical units. For example, consumption of electricity is expressed in kilowatt-hours, coal in tons, natural gas in cubic feet, and petroleum products (fuel oil, motor gasoline, etc.) in gallons.

Appendix A
COMPUTER PROGRAM

COMPUTER MODEL

One main routine and several subroutines are used in the computer program. A brief description of each follows.

Main. The main routine primarily does the bookkeeping for the model. It sets up the initial conditions and performs the executive function of calling for the appropriate subroutines.

Subroutine Read. Reads input data for the program element to be analyzed.

Subroutine Element. Calculates direct energy consumption based on flying hours and consumption rates for each program element and accumulates direct energy consumption for all program elements. This accumulated direct energy sum is used to calculate direct support energy and ancillary support energy. Definitions of the terms used in this subroutine follow (I = year):

Aircraft

$G(1,I)$ = aircraft fuel, gal, for each aircraft, each year

$G(2,I)$ = aircraft fuel, Btu, for each aircraft, each year

Sum (1) = aircraft fuel, gal, for each aircraft, all years

Sum (2) = aircraft fuel, Btu, for each aircraft, all years

Missiles

$G(1,I)$ = electricity, kWh, for each missile, each year

$G(2,I)$ = diesel fuel, gal, for each missile, each year

$G(3,I)$ = diesel fuel, Btu, for each missile, each year

Sum (1) = kWh, for each missile, all years

Sum (2) = gal, for each missile, all years

Sum (3) = Btu, for each missile, all years

Sums for Each Program

Sums $(1,I)$ = jet fuel, gal

Sums $(2,I)$ = other type fuel, gal

Sums (3,I) = electricity, kWh

Sums (4,I) = diesel fuel, gal

Sums (5,I) = diesel fuel, Btu

Sums for All Programs

Sums (6,I) = electricity for missiles, kWh converted to Btu[*]

Sums (7,I) = diesel fuel for missiles, gal converted to Btu[*]

Sums (8,I) = jet fuel, gal

Sums (9,I) = other fuel, gal

Sums (10,I) = electricity, kWh

Sums (11,I) = diesel fuel, gal

Sums (12,I) = total Btu

Subroutine Out1. Prints tables of direct energy consumption by program and total direct energy consumption for all programs.

Subroutine Supp. Calculates direct support energy consumption and ancillary support energy consumption as a percent of total direct energy consumption by all program elements.

Subroutine Out2. Prints tables of ancillary support energy consumption, direct support energy consumption, and a summary of total Air Force energy consumption.

Subroutine Dump. Prints out all input data for each program element if so requested.

---

[*] Separately accounted for and subtracted from ancillary support energy totals.

```
      1                 KOUNT, LINES, NELEM, NPAGE, NPROG, NRUN, ELEM(3),
      2                 PROG(18), RUN(18)
C
C      MAIN ROUTINE FOR AIR FORCE ENERGY CONSUMPTION MODEL
C
C      PRINT HEADING ON SEPARATE PAGE.
   10 WRITE (6, 20)
   20 FORMAT (1H1//////////// T40, 'A I R   F O R C E   E N E R G Y  ',
      1 'C O N S U M P T I O N   M O D E L' )
C      SET RUN COUNTER TO ZERO.
      NRUN = 0
C      SET CLEAR DESIGNATOR TO 1.
      F(67) = 1.
C      START OF RUN LOOP.
C      SET PAGE NUMBER TO 1.
   30 NPAGE = 1
C      STEP RUN COUNTER BY 1.
      NRUN = NRUN + 1
C      SET VARIOUS DIRECT ENERGY TOTALS TO ZERO.
      DO 40 I = 6, 12
      DO 35 J = 1, 11
      SUMS(I,J) = 0.
   35 CONTINUE
   40 CONTINUE
C      READ RUN TITLE.
      READ (5, 50) (RUN(I), I = 1, 18)
   50 FORMAT (18A4)
C      READ BASE YEAR.
      READ (5, 60) NYEAR(1)
   60 FORMAT (I4)
C      CALCULATE REMAINING NINE YEARS.
      DO 70 I = 2, 10
      NYEAR(I) = NYEAR(I-1) + 1
   70 CONTINUE
C      SET PROGRAM COUNTER TO ZERO.
      NPROG = 0
C      START OF PROGRAM LOOP.
C      READ PROGRAM NAME CARD.
   80 READ (5, 50) (PROG(I), I = 1, 18)
C      PRINT HEADINGS ON NEW PAGE.
      WRITE (6, 90) (RUN(I), I = 1, 18), NPAGE, (PROG(I), I = 1, 18),
      1 (NYEAR(I), I = 1, 10)
   90 FORMAT (1H1/ T3, 18A4, T122, 'PAGE   ', I3  // T58,'CONSUMPTION ',
      1 'RATES' / T38, '(GAL IN MILLIONS, KWH IN BILLIONS, BTU''S IN ',
      2 'TRILLIONS)' // T3, 18A4 /// T25, 10(I4, 6X), T127, 'TOTAL')
C      STEP PAGE NUMBER BY 1.
      NPAGE = NPAGE + 1
C      SET LINES COUNTER TO 10.
      LINES = 10
C      STEP PROGRAM COUNTER BY 1.
      NPROG = NPROG + 1
C      SET VARIOUS PROGRAM TOTALS TO ZERO.
      DO 110 I = 1, 5
      DO 100 J = 1, 11
      SUMS(I,J) = 0.
  100 CONTINUE
  110 CONTINUE
```

```
C      SET PROGRAM ELEMENT COUNTER TO ZERO.
       NELEM = 0
C      START OF PROGRAM ELEMENT LOOP.
C      CLEAR ALL INPUT VARIABLES IN COMMON IF DESIGNATED.
   120 IF (F(67) .NE. 1.) GO TO 140
       DO 130 I = 1, 80
       F(I) = 0.
   130 CONTINUE
C      STEP PROGRAM ELEMENT COUNTER BY 1.
   140 NELEM = NELEM + 1
C      READ IN DATA
       CALL READ
C      CALCULATE OUTPUT BY PROGRAM ELEMENT
       CALL ELEMNT
C      PRINT RESULTS BY PROGRAM ELEMENT.
       CALL OUT1
C      BRANCH DEPENDING ON END DESIGNATOR.
       IF (IEND .EQ. 666) GO TO 120
       IF (IEND .EQ. 777) GO TO 80
C      CALCULATE DIRECT SUPPORT, ANCILLARY SUPPORT AND AIR FORCE TOTALS.
   150 CALL SUPP
       IF (IEND .EQ. 888) GO TO 30
C      PRINT TERMINATION STATEMENT ON NEW PAGE.
       WRITE (6, 160)
   160 FORMAT (1H1/T10,'ALL DATA HAVE BEEN PROCESSED -- JOB TERMINATED.')
       CALL EXIT
       END
       SUBROUTINE READ
       COMMON     F(80), G(8,11), SUM(11), SUMS(12,11), NYEAR(10), IEND,
      1            KOUNT, LINES, NELEM, NPAGE, NPROG, NRUN, ELEM(3),
      2            PROG(18), RUN(18)
       DIMENSION  F1(6), I1(6)
C
C      SUBROUTINE FOR READING IN DATA
C
C      READ PROGRAM ELEMENT NAME.
    10 READ (5, 20) (ELEM(I), I = 1, 3)
    20 FORMAT (3A4)
       I = 0
C      READ DATA CARDS.
    30 READ (5, 40) (I1(K), F1(K), K = 1, 6)
    40 FORMAT (6(I3, F8.0, 1X))
       DO 50 K = 1, 6
       IF (I1(K) .GT. 80) GO TO 60
       IF (I1(K) .EQ. 0 .AND. F1(K) .EQ. 0.) GO TO 50
       IF (I1(K) .EQ. 0 .AND. F1(K) .NE. 0.) GO TO 110
       IF (I1(K) .LT. 0) GO TO 110
       I = I1(K)
       F(I) = F1(K)
    50 CONTINUE
       GO TO 30
    60 IEND = I1(K)
       IF (IEND .NE. 666 .AND. IEND .NE. 777 .AND. IEND .NE. 888 .AND.
      1 IEND .NE. 999) GO TO 110
       IF (F(69) .EQ. 0.) F(69) = 1.0
C      ROUTINE FOR REPEATING INPUT DATA
       K = 1
```

```
      L = 0
   70 L = L + 10
   80 K = K + 1
      IF (K .GT. 60) RETURN
      IF (K .EQ. L) GO TO 70
      IF (F(K) .NE. (-1.)) GO TO 80
      DO 90 J = K, L
      IF (F(J) .EQ. (-2.)) GO TO 100
      F(J) = F(J-1)
   90 CONTINUE
      K = L
      GO TO 70
  100 F(J) = F(J-1)
      K = J
      GO TO 80
C     PRINT ERROR MESSAGE.
  110 WRITE (6, 120) I
  120 FORMAT (1H0/ T5, 'AN INDEX FOR AN INPUT VARIABLE HAS NOT BEEN ',
     1 'ENTERED PROPERLY.  THE LAST CORRECT INDEX WAS ', I3, '.' / T5,
     2 'THIS JOB HAS BEEN TERMINATED.' )
      CALL EXIT
      END
      SUBROUTINE ELEMNT
      COMMON       F(80), G(8,11), SUM(11), SUMS(12,11), NYEAR(10), IEND,
     1             KOUNT, LINES, NELEM, NPAGE, NPROG, NRUN, ELEM(3),
     2             PROG(18), RUN(18)
C
C
C     SUBROUTINE FOR CALCULATING ENERGY COSUMPTION BY PROGRAM ELEMENT
C
C     SET VARIOUS TOTALS TO ZERO.
      SUM(1) = 0.
      SUM(2) = 0.
      SUM(3) = 0.
C     CONSTANT TO CONVERT PHYSICAL UNITS TO MILLIONS
C     AND BTU'S TO TRILLIONS
      D1 = 10. ** (-6)
C     CONSTANT TO CONVERT KWH TO BILLIONS
      D2 = 10. ** (-9)
C     TEST IF PROGRAM ELEMENT IS MISSILE.
      IF (F(61) .GT. 3.) GO TO 40
C     START LOOP TO CALCULATE AIRCRAFT ENERGY CONSUMPTION BY YEAR.
      DO 30 I = 1, 10
C     IF HYPOTHETICAL AIRCRAFT AND NO FC/FH ESTIMATED, CALCULATE FC/FH.
      IF (F(61) .EQ. 3.) F(I+30)=F(64)*F(I+40)**F(65)*F(I+50)**F(66)
C     GALLONS CONSUMED
C     TEST FOR TYPE OF FLYING HOUR INPUT.
      G(1,I) = F(I+20) * F(I+30) * D1
      IF (F(I+10) .EQ. 1.) G(1,I) = G(1,I) * F(I)
C     BTU'S CONSUMED
      G(2,I) = G(1,I) * F(63) * D1
C     SUM GAL'S AND BTU'S FOR ALL YEARS AND ALL PROGRAM ELEMENTS.
      SUM(1) = SUM(1) + G(1,I)
      SUM(2) = SUM(2) + G(2,I)
      SUMS(5,I) = SUMS(5,I) + G(2,I)
C     SUM FOR ALL PROGRAMS.
      SUMS(12,I) = SUMS(12,I) + G(2,I)
C     IF HYPOTHETICAL AIRCRAFT, DETERMINE FUEL TYPE
```

```fortran
      IF (F(61) .NE. 1.) GO TO 20
      SUMS(1,I) = SUMS(1,I) + G(1,I)
      SUMS(8,I) = SUMS(8,I) + G(1,I)
      GO TO 30
   20 IF (F(62) .EQ. 2.) GO TO 25
      SUMS(1,I) = SUMS(1,I) + G(1,I)
      SUMS(8,I) = SUMS(8,I) + G(1,I)
      GO TO 30
   25 SUMS(2,I) = SUMS(2,I) + G(1,I)
      SUMS(9,I) = SUMS(9,I) + G(1,I)
   30 CONTINUE
C     DONE FOR AIRCRAFT. RETURN.
      RETURN
   40 CONST1 = 10500.
      CONST2 = 139000.
C     START LOOP TO CALCULATE MISSILE ENERGY CONSUMPTION BY YEAR.
      DO 50 I = 1, 10
C     ELECTRICITY CONSUMED, KWH AND BTU'S.
      G(1,I) = F(I) * F(70) * 02
      BTUKWH = G(1,I) * CONST1 * .001
C     DIESEL FUEL CONSUMED, GAL'S AND BTU'S.
      G(2,I) = F(I) * F(71) * 01
      BTUDSL = G(2,I) * CONST2 * 01
      G(3,I) = BTUKWH + BTUDSL
C     SUM KWH'S, GAL'S AND BTU'S FOR ALL YEARS AND ALL PROGRAM ELEMENTS.
      SUM(1) = SUM(1) + G(1,I)
      SUM(2) = SUM(2) + G(2,I)
      SUM(3) = SUM(3) + G(3,I)
      SUMS(3,I) = SUMS(3,I) + G(1,I)
      SUMS(4,I) = SUMS(4,I) + G(2,I)
      SUMS(5,I) = SUMS(5,I) + G(3,I)
C     SUM FOR ALL PROGRAMS.
      SUMS(6,I) = SUMS(6,I) + BTUKWH
      SUMS(7,I) = SUMS(7,I) + BTUDSL
      SUMS(10,I) = SUMS(10,I) + G(1,I)
      SUMS(11,I) = SUMS(11,I) + G(2,I)
      SUMS(12,I) = SUMS(12,I) + G(3,I)
   50 CONTINUE
C     DONE FOR MISSILES, RETURN
   60 RETURN
      END
      SUBROUTINE OUT1
      COMMON      F(80), G(8,11), SUM(11), SUMS(12,11), NYEAR(10), IEND,
     1            KOUNT, LINES, NELEM, NPAGE, NPROG, NRUN, ELEM(3),
     2            PROG(18), RUN(18)
      DIMENSION IUE(10), IFH(10)
C
C     SUBROUTINE FOR PRINTING DIRECT ENERGY SUMMARY TABLES
C
C     TEST IF PROGRAM ELEMENT IS MISSILE.
   10 IF (F(61) .GT. 3.) GO TO 30
C     PRINT AIRCRAFT DATA.
      IF (F(62) .EQ. 1.) WRITE (6, 18) (ELEM(I), I = 1, 3),
     1 (((G(I,J), J = 1, 10), SUM(I)), I = 1, 2)
      IF (F(62) .EQ. 2.) WRITE (6, 20) (ELEM(I), I = 1, 3),
     1 (((G(I,J), J = 1, 10), SUM(I)), I = 1, 2)
   18 FORMAT (1H0, T5, 3A4 / T11, 'GAL-JET', T23, 10(F8.3, 2X), T124,
```

```fortran
     1 F9.3 / T11, 'BTU', T23, 10(F8.3, 2X), T124, F9.3)
  20 FORMAT (1H0, T5, 3A4 / T11, 'GAL-OTH', T23, 10(F8.3, 2X), T124,
     1 F9.3 / T11, 'BTU', T23, 10(F8.3, 2X), T124, F9.3)
C        STEP LINES COUNTER BY 4.
         LINES = LINES + 4
         IF (F(68) .NE. 0.) GO TO 46
         DO 22 I = 1, 10
         IUF(I) = F(I)
         IFH(I) = F(I+20)
  22 CONTINUE
         WRITE (6,24) (IUF(I), I = 1, 10), (IFH(I), I = 1, 10)
  24 FORMAT (1H / T12, 'UF', T23, 10(I8, 2X) / T12, 'FH', T23,
     1 10(I8, 2X))
         LINES = LINES + 3
         GO TO 50
C        PRINT MISSILE DATA.
  30 WRITE (6, 40) (ELEM(I), I = 1, 3), (((G(I,J), J = 1, 10), SUM(I)),
     1 I = 1, 3)
  40 FORMAT (1H0, T5, 3A4 / T11, 'KWH-ELEC', T23, 10(F8.3, 2X), T124,
     1 F9.3 / T11, 'GAL-OSL', T23, 10(F8.3, 2X), T124, F9.3 / T11,
     2 'BTU', T23, 10(F8.3, 2X), T124, F9.3)
C        STEP LINES COUNTER BY 5.
         LINES = LINES + 5
         IF (F(68) .NE. 0.) GO TO 46
         DO 42 I = 1, 10
         IUF(I) = F(I)
  42 CONTINUE
         WRITE (6, 44) (IUF(I), I = 1, 10)
  44 FORMAT (1H / T12, 'UF', T23, 10(I8, 2X))
         LINES = LINES + 2
         GO TO 50
C        PRINT INPUT DUMP IF DESIGNATED.
  46 CALL DUMP
C        CHECK POSITION ON PAGE.
  50 IF (LINES .LT. 51) GO TO 70
C        PRINT HEADINGS ON NEW PAGE.
         WRITE (6, 60) (RUN(I), I = 1, 18), NPAGE, (PROG(I), I = 1, 18),
     1 (MYEAR(I), I = 1, 10)
  60 FORMAT (1H1/ T3, 18A4, T122, 'PAGE ', I3 // T58,'CONSUMPTION ',
     1 'RATES' / T38, '(GAL IN MILLIONS, KWH IN BILLIONS, BTU''S IN ',
     2 'TRILLIONS)' // T3, 18A4 /// T25, 10(I4, 6X), T127, 'TOTAL')
C        RESET LINE COUNTER.
         LINES = 10
C        STEP PAGE COUNTER.
         NPAGE = NPAGE + 1
C        RETURN AND CALCULATE NEXT PROGRAM ELEMENT.
  70    IF (IEND .EQ. 666) RETURN
C        CALCULATE CURRENT TOTALS.
         DO 90 I = 1, 5
         DO 80 J = 1, 10
         SUMS(I,11) = SUMS(I,11) + SUMS(I,J)
  80 CONTINUE
  90 CONTINUE
C        PRINT PROGRAM TOTALS
         WRITE (6, 100) ((SUMS(I,J), J = 1, 11), I = 1, 5)
 100 FORMAT (1H // T5, 'SUBTOTAL' / T11,'GAL-JET', T23, 10(F8.3, 2X),
     1 T124, F9.3 / T11, 'GAL-OTH', T23, 10(F8.3, 2X), T124, F9.3 / (11,
```

```
      2 'KWH-ELEC', T23, 10(F8.3, 2X), T124, F9.3 / T11, 'GAL-DSL', T23,
      3 10(F8.3, 2X), T124, F9.3 / T11, 'BTU', T23, 10(F8.3, 2X), T124,
      4 F9.3)
        LINES = LINES + 8
        IF (IEND .LT. 888) RETURN
        DO 120 I = 8, 12
        DO 110 J = 1, 10
        SUMS(I,11) = SUMS(I,11) + SUMS(I,J)
  110 CONTINUE
  120 CONTINUE
        IF (LINES .LT. 48) GO TO 140
        WRITE (6, 130) (RUN(I), I = 1, 18), NPAGE, (NYEAR(I), I = 1, 10)
  130 FORMAT (1H1/ T3, 18A4, T122, 'PAGE   ', I3 // T58, 'CONSUMPTION ',
      1 'RATES' / T38, '(GAL IN MILLIONS, KWH IN BILLIONS, BTU''S IN ',
      2 'TRILLIONS)' /// T25, 10(I4, 6X), T127, 'TOTAL')
        NPAGE = NPAGE + 1
C       PRINT TOTALS FOR ALL PROGRAMS
  140 WRITE (6, 150) ((SUMS(I,J), J = 1, 11), I = 8, 12)
  150 FORMAT (1H0/ T42, '* * * * * * * * * * * * * * * * * * * * * ',
      1 '* * * *' // T56, 'TOTALS FOR ALL PROGRAMS' // T11, 'GAL-JET',
      2 T23, 10(F8.3, 2X), T124, F9.3 / T11, 'GAL-OTH', T23, 10(F8.3,2X),
      3 T124, F9.3 / T11, 'KWH-ELEC', T23, 10(F8.3, 2X), T124, F9.3 /
      4 T11, 'GAL-DSL', T23, 10(F8.3, 2X), T124, F9.3 / T11, 'BTU', T23,
      5 10(F8.3, 2X), T124, F9.3)
        RETURN
        END
        SUBROUTINE SUPP
        COMMON     F(80), G(8,11), SUM(11), SUMS(12,11), NYEAR(10), IEND,
      1            KOUNT, LINES, NELEM, NPAGE, NPROG, NRUN, ELEM(3),
      2            PROG(18), RUN(18)
C
C       SUBROUTINE FOR CALCULATING ANCILLARY AND DIRECT SUPPORT AND
C       AIR FORCE TOTAL ENERGY CONSUMPTION
C
C       CLEAR VARIOUS TOTALS.
   10 DO 20 I = 1, 11
        SUMS(1,I) = 0.
        SUMS(2,I) = 0.
        SUMS(3,I) = 0.
        SUM(I) = 0.
   20 CONTINUE
C       CONSTANT TO CONVERT PERCENT TO DECIMAL.
        D2 = .01
C       MOTOR GAS CONVERSION FACTOR - BTU'S TRILLIONS TO MILLION GAL'S.
        CONST1 = .125
C       DISTILATE CONVERSION FACTOR - BTU'S TRILLIONS TO MILLION GAL'S.
        CONST2 = .139
C       RESIDUAL CONVERSION FACTOR - BTU'S TRILLIONS TO MILLION GAL'S.
        CONST3 = .15
C       NAVY SPECIAL CONVERSION FACTOR - BTU'S TRILLIONS TO MILLION GAL'S.
        CONST4 = .15
C       MODIFY DIRECT ENERGY AS PERCENT OF TOTAL FORCE
        DO 25 I = 1, 11
        SUMS(12,I) = SUMS(12,I) / F(69)
   25 CONTINUE
C       CALCULATE DIRECT SUPPORT ENERGY.
        DO 30 I = 1, 10
```

```
C       TOTAL BTU'S OF ALL PROGRAMS BY YEAR.
        TEMP = SUMS(12,I)
C       MOTOR GASOLINE, GAL'S AND BTU'S
        G(2,I) = TEMP * F(72) * D2
        G(1,I) = G(2,I) / CONST1
C       DISTILLATE OIL, GAL'S AND BTU'S
        G(4,I) = TEMP * F(73) * D2
        G(3,I) = G(4,I) / CONST2
C       RESIDUAL FUEL, GAL'S AND BTU'S
        G(6,I) = TEMP * F(74) * D2
        G(5,I) = G(6,I) / CONST3
C       NAVY SPECIAL FUEL, GAL'S AND BTU'S
        G(8,I) = TEMP * F(75) * D2
        G(7,I) = G(8,I) / CONST4
C       SUM BTU'S FOR DIRECT SUPPORT BY YEAR
        SUMS(1,I) = SUMS(1,I) + G(2,I) + G(4,I) + G(6,I) + G(8,I)
  30    CONTINUE
        DO 50 J = 1, 10
        SUMS(1,11) = SUMS(1,11) + SUMS(1,J)
C       SUM FOR DIRECT SUPPORT ACROSS ALL YEARS.
        DO 40 I = 1, 8
        SUM(I) = SUM(I) + G(I,J)
  40    CONTINUE
  50    CONTINUE
C       SET FORMAT COUNTER FOR DIRECT SUPPORT PRINT ROUTINE
        KOUNT = 1
C       PRINT RESULTS
        CALL OUT2
C       SET FORMAT COUNTER FOR ANCILLARY SUPPORT PRINT ROUTINE
        KOUNT = 2
C       ELECTRICITY CONVERSION FACTOR - BTU'S TRILLIONS TO BILLION KWH
        CONST5 = 10.5
C       FUEL OIL CONVERSION FACTOR - BTU'S TRILLIONS TO MILLION GAL'S.
        CONST6 = .139
C       COAL CONVERSION FACTOR - BTU'S TRILLIONS TO MILLION TONS
        CONST7 = 25.
C       NATURAL GAS CONVERSION FACTOR - BTU'S TRILLIONS TO BILLION CU. FT.
        CONST8 = 1.03
C       CALCULATE ANCILLARY SUPPORT ENERGY
        DO 60 I = 1, 10
        SUM(I) = 0.
        TEMP = SUMS(12,I)
C       ELECTRICITY, KWH'S AND BTU'S (SUBTRACT OUT MISSILE ENERGY)
        G(2,I) = TEMP * F(76) * D2 - SUMS(6,I)
        G(1,I) = G(2,I) / CONST5
C       FUEL OIL, GAL'S AND BTU'S (SUBTRACT OUT MISSILE ENERGY)
        G(4,I) = TEMP * F(77) * D2 - SUMS(7,I)
        G(3,I) = G(4,I) / CONST6
C       COAL, TONS AND BTU'S
        G(6,I) = TEMP * F(78) * D2
        G(5,I) = G(6,I) / CONST7
C       NATURAL GAS, CU. FT. AND BTU'S
        G(8,I) = TEMP * F(79) * D2
        G(7,I) = G(8,I) / CONST8
        SUMS(2,I) = SUMS(2,I) + G(2,I) + G(4,I) + G(6,I) + G(8,I)
  60    CONTINUE
C       SUM ANCILLARY SUPPORT ENERGY & TOTAL AIR FORCE ENERGY BY YEAR
```

```
      DO 80 J = 1, 10
      SUMS(3,J) = SUMS(3,J) + SUMS(1,J) + SUMS(2,J) + SUMS(12,J)
      SUMS(2,11) = SUMS(2,11) + SUMS(2,J)
C     SUM ACROSS YEARS
      DO 70 I = 1, 8
      SUM(I) = SUM(I) + G(I,J)
   70 CONTINUE
   80 CONTINUE
C     AIR FORCE ENERGY CONSUMPTION TOTAL FOR ALL YEARS
      SUMS(3,11) = SUMS(1,11) + SUMS(2,11) + SUMS(12,11)
C     PRINT RESULTS
      CALL OUT2
      RETURN
      END
      SUBROUTINE OUT2
      COMMON     F(80), G(8,11), SUM(11), SUMS(12,11), NYEAR(10), IEND,
     1           KOUNT, LINES, NELEM, NPAGE, NPROG, NRUN, ELEM(3),
     2           PROG(18), RUN(18)
C
C     SUBROUTINE TO PRINT ANCILLARY AND DIRECT SUPPORT AND TOTAL AIR
C     FORCE SUMMARY TABLES
C
C     FORMAT COUNTER
   10 IF (KOUNT .EQ. 2) GO TO 90
      WRITE (6, 20) (RUN(I), I = 1, 18), NPAGE, (NYEAR(I), I = 1, 10)
   20 FORMAT (1H1/ T3, 18A4, T122, 'PAGE   ', I3 / T31, '(GAL, TON, ',
     1'IN MILLIONS, KWH, CUFT IN BILLIONS, BTU''S IN TRILLIONS)'// T26,
     2 10(I4, 6X), T126, 'TOTAL' // T3, 'DIRECT SUPPORT')
      WRITE (6, 30)
   30 FORMAT (1H0, T5, 'MOTOR GASOLINE')
      WRITE (6, 40) (((G(I,J), J = 1, 10), SUM(I)), I = 1, 2)
   40 FORMAT (1H , T14, 'GAL', T23, 10(F8.3, 2X), T124, F9.3 / T14,
     1 'BTU', T23, 10(F8.3, 2X), T124, F9.3)
      WRITE (6, 50)
   50 FORMAT (1H0, T5, 'DISTILLATE FUEL')
      WRITE (6, 40) (((G(I,J), J = 1, 10), SUM(I)), I = 3, 4)
      WRITE (6, 60)
   60 FORMAT (1H0, T5, 'RESIDUAL FUEL')
      WRITE (6, 40) (((G(I,J), J = 1, 10), SUM(I)), I = 5, 6)
      WRITE (6, 70)
   70 FORMAT (1H0, T5, 'NAVY SPECIAL FUEL OIL')
      WRITE (6, 40) (((G(I,J), J = 1, 10), SUM(I)), I = 7, 8)
      WRITE (6, 80) (SUMS(1,I), I = 1, 11)
   80 FORMAT (1H0, T5, 'TOTAL' / T14, 'BTU', T23, 10(F8.3, 2X), T124,
     1 F9.3)
C     DIRECT SUPPORT PRINTED - RETURN TO CALCULATE ANCILLARY SUPPORT
      RETURN
C
C     PRINT ANCILLARY SUPPORT TABLES
   90 WRITE (6, 100)
  100 FORMAT(1H0// T3, 'ANCILLARY SUPPORT')
      WRITE (6, 110) (((G(I,J), J = 1, 10), SUM(I)), I = 1, 2)
  110 FORMAT (1H0, T5, 'ELECTRICITY' / T14, 'KWH', T23, 10(F8.3, 2X),
     1 T124, F9.3 / T14, 'BTU', T23, 10(F8.3, 2X), T124, F9.3)
      WRITE (6, 120) (((G(I,J), J = 1, 10), SUM(I)), I = 3, 4)
  120 FORMAT (1H0/ T5, 'FUEL OIL' / T14, 'GAL', T23, 10(F8.3, 2X), T124,
     1 F9.3 / T14, 'BTU', T23, 10(F8.3, 2X), T124, F9.3)
```

```fortran
      WRITE (6, 130) (((G(I,J), J = 1, 10), SUM(I)), I = 5, 6)
  130 FORMAT (1H0, T5, 'COAL' / T14, 'TON', T23, 10(F8.3, 2X), T124,
     1 F9.3 / T14, 'BTU', T23, 10(F8.3, 2X), T124, F9.3)
      WRITE (6, 140) (((G(I,J), J = 1, 10), SUM(I)), I = 7, 8)
  140 FORMAT (1H0, T5, 'NATURAL GAS' / T14, 'CUFT', T23, 10(F8.3, 2X),
     1 T124, F9.3 / T14, 'BTU', T23, 10(F8.3, 2X), T124, F9.3)
      WRITE (6, 150) (SUMS(2,I), I = 1, 11)
  150 FORMAT (1H0/ T5, 'TOTAL' / T14, 'BTU', T23, 10(F8.3, 2X), T124,
     1 F9.3)
C     PRINT TOTAL ENERGY SUMMARY TABLE
      WRITE (6,160) (NYEAR(I), I = 1, 10)
  160 FORMAT (1H1/////// T36, 'A I R   F O R C E   E N E R G Y ',
     1 'C O N S U M P T I C N   M O D E L' // T55, 'S U M M A R Y ',
     2 'T A B L E' // T57, '(BTU''S IN TRILLIONS)' //// T25, 10(I4, 6X),
     3 T127, 'TOTAL')
      WRITE (6,170) (SUMS(12,I), I = 1, 11), ((SUMS(J,I), I = 1, 11),
     1 J = 1, 3)
  170 FORMAT (1H0, T3, 'TOTAL DIRECT ENERGY' // T23, 10(F8.3, 2X),
     1 T124, F9.3 /// T3, 'TOTAL DIRECT SUPPORT ENERGY' // T23,
     2 10(F8.3, 2X), T124, F9.3 /// T3, 'TOTAL ANCILLARY SUPPORT ',
     3 'ENERGY' // T23, 10(F8.3, 2X), T124, F9.3 //// T3, 'USAF TOTAL ',
     4 'ENERGY CONSUMPTION' // T23, 10(F8.3, 2X), T124, F9.3)
      RETURN
      END
      SUBROUTINE DUMP
      COMMON    F(80), G(8,11), SUM(11), SUMS(12,11), NYEAR(10), IEND,
     1          KOUNT, LINES, NELEM, NPAGE, NPROG, NRUN, ELEM(3),
     2          PROG(18), RUN(18)
C
C     SUBROUTINE FOR PRINTING INPUT DUMP IF DESIGNATED.
C
   10 WRITE (6, 20)
   20 FORMAT (1H0, T15, 'INPUT DUMP', T126, 'INDEXES')
C     PRINT INPUT AND INDEXES.
      DO 50 I = 1, 80, 10
      J = I + 9
      WRITE (6, 40) (F(K), K = I, J), I, J
   40 FORMAT (1H , T21, 10(F9.2, 1X), T127, I2, '-', I2)
   50 CONTINUE
C     STEP LINE COUNTER.
      LINES = LINES + 10
      RETURN
      END
```

0499

```
TEST RUN NO. 1
1972
STRATEGIC PROGRAM I
B-99
061       1 072      2.11 073      5.71 074      1.23 075       .61 076      13.12
077    4.26 078      2.81 079      5.37 062         1 063   119000
001     400 002        -1 005        -2 006       350 007       340 008        330
009     320 010       310 021    400000 022    390000 023    380000 024     370000
025     900 026      1000 027        -1 011         2 012        -1 014         -2
015       1 016        -1 031      3500 032        -1
666
B-78
061       1 001       500 002       480 003       460 004       440 005        420
006     400 007       380 008       360 009       340 010       320 011          2
012      -1 021    500000 022    480000 023    460000 024    440000 025     420000
015      -2 016         1 017        -1 026      1000 027        -1 031       1800
032      -1
666
LB-1
061       2 001        90 002        -1 011         2 012        -1 021     185000
022      -1 031      1200 032        -1 062         2 063    476000 068          1
666
LB-2
061       3 001       400 002        -1 011         2 012        -1 021     570000
022      -1 041       700 042        -1 051     40000 052        -1 031          0
032      -1 062         1 063    119000 064      .657 065      .094 066       .642
666
CC-III
061       4 070    350000 071      1165 001       990 002       980 003        970
004     960 005       950 006       940 007       930 008       920 009        910
010     900
011       0 012        -1 021         0 022        -1 031         0 032         -1
041       0 042        -1 051         0 052        -1
068       0
666
XX-V
061       4 001       500 002       490 003       480 004       470 005        460
006     450 007       440 008       430 009       420 010       410
068       1
777
GENERAL PURPOSE PROGRAM II
F-79
061       1 001       500 002       480 003       460 004       440 005        420
006     400 007       380 008       360 009       340 010       320 011          1
012      -1 021      1000 022        -1 031      1800 032        -1 068          1
777
AIRLIFT AND SEALIFT PROGRAM IV
C-600
061       1 001       400 002       390 003       380 004       370 005        360
006     350 007       340 008       330 009       320 010       310 011          1
012      -1 021      1000 022        -1 031      3500 032        -1 068          0
068       0
666
LB-1
061       2 001        90 002        -1 011         2 012        -1 021     185000
022      -1 031      1200 032        -1 062         2 063    476000 068          0
666
LB-2
061       3 001       400 002        -1 011         2 012        -1 021     570000
022      -1 041       700 042        -1 051     40000 052        -1 031          0
032      -1 062         1 063    119000 064      .657 065      .094 066       .642
999
```

Appendix B
CONVERSION FACTORS

Listed below are the factors used in the model to convert energy
units into physical units and vice versa. Data were obtained from a
variety of sources that included Bu Mines, ASTM, API, and the Air Force.

Item	Divide	By	To Obtain
Jet fuel	Btu	119,000	gal
Aviation gas	Btu	114,000	gal
Motor gasoline	Btu	125,000	gal
Distillate fuel	Btu	139,000	gal
Residual fuel	Btu	150,000	gal
Navy special fuel oil (NSFO)	Btu	150,000	gal
Electricity	Btu	10,500	kWh
Fuel oil (heating)	Btu	139,000	gal
Coal	Btu	25,000,000	tons
Natural gas	Btu	1,030	cu/ft

Appendix C
ENERGY ESTIMATING RELATIONSHIPS

Energy estimating relationships (EERs) are given for bomber/recon, cargo/transport, and fighter/recon aircraft. Tables of the fuel consumption rate, both actual and computed, are given for each category of aircraft along with the data used to generate the EERs using multiple regression techniques.

Table C-1

BOMBER/RECON AIRCRAFT EERs[a]

Aircraft	Cruise Speed, kn	Gross Weight, lb	Fuel Consumption, gal/hr	
			Actual	Computed
B-47	490	200,000	2,100	2,000
B-52E	520	450,000	3,715	3,289
B-57	418	58,800	830	829
B-58A	538	163,000	2,400	2,162
B-66B	496	83,000	1,300	1,347
EC-135C	523	301,600	2,130	2,748

[a] $F.C. = 5.45 \times 10^{-5} V^{1.874} W^{0.476}$

$R^2 = 0.93$, $SE = 459.8$, and

where F.C. = fuel consumption rate, gal/hr
  V = cruise speed,
  W = gross weight, lb
  R^2 = multiple correlation coefficient
  SE = standard error of estimate

Table C-2

CARGO/TRANSPORT AIRCRAFT EERs[a]

Aircraft	Cruise Speed, kn	Gross Weight, lb	Fuel Consumption, gal/hr	
			Actual	Computed
C-5A	490	719,000	3,550	2,958
C-9	503	10,800	1,075	734
C-10A	241	14,600	75	97
C-130A	330	124,200	800	510
C-135B	523	248,000	2,000	2,460
C-140A	473	40,470	680	976
C-141	496	316,600	2,180	2,299
KC-135A	522	300,800	2,200	2,617

[a]$F.C. = 4.43 \times 10^{-7} V^{2 \cdot 89} W^{0 \cdot 35}$

$R^2 = 0.936$, $SE = 454.4$.

Table C-3

FIGHTER/RECON AIRCRAFT EERs[a]

Aircraft	Cruise Speed, kn	Gross Weight, lb	Fuel Consumption gal/hr	
			Actual	Computed
F-4	1,221	49,311	1,400	1,320
F-5A	565	13,663	560	539
F-84D	481	16,827	600	606
F-86A	522	15,876	580	589
F-89	489	36,824	1,140	1,004
F-100C	713	32,536	1,000	961
F-100D	775	38,048	950	1,071
F-101	873	48,000	1,250	1,257
F-102A	557	28,150	735	856
F-104	1,145	22,145	825	785
F-105B	750	46,998	1,400	1,223
F-106	1,136	34,239	1,020	1,037
F-111	1,196	92,655	1,875	1,975

[a] $F.C. = 0.657 \, V^{.094} W^{.642}$

$R^2 = 0.951$, SE = 99.7.

Appendix D

ENERGY REQUIREMENTS FOR ICBMs

ICBMs use energy in far different ways than do aircraft. While training and maintenance of flying proficiency require that aircraft b: flown, and thus use jet fuel, the ICBM fleet is never flown, for all practical purposes. Instead, the missiles are maintained in a state of readiness for that time when they will be needed. This state of readiness requires that the missiles remain in an environment in which the temperature and humidity are controlled and that certain of the electrical components of the missile be kept activated. In addition, an electrical system monitors the missile systems and the crew operates in an underground control center. These activities require energy which is largely supplied by local electrical utilities; however, diesel fuel is used at the missile complexes for heat, the operation of emergency electrical generators, and certain other equipment.

Data were obtained on the consumption of electricity and diesel fuel during 1972 for the six Minuteman bases which house the entire fleet of 1000 missiles. These data were then used to derive averag values per missile for the electricity (350,000 kWh) and diesel oil (1165 gal) consumption of the complexes. (See Tables D-1 and D-2.) This energy is completely separate from energy consumed at the bases which support the complexes. This latter energy falls into the category of ancillary support and is estimated in a different section of the model.

Derivation of the ICBM electrical energy requirements was done by simply summing the 1972 requirements for the six Minuteman bases and then dividing by 1000 to obtain the average consumption per missile. This procedure averages a number of peculiarities of the individual bases, such as increased floodlighting and varieties in basic design that are not of interest at the degree of aggregation at which the model will be used.

Table D-1

1972 ICBM ELECTRICAL ENERGY CONSUMPTION

ICBM Base	Consumption, kWh
Minot	55,334,040
Whiteman	51,484,100
Malmstrom	60,343,447
Grand Forks	80,854,755
F. E. Warren	66,041,760
Ellsworth	34,571,411
Total	348,629,513

or about 350,000 kWh per missile

Table D-2

1972 ICBM DIESEL OIL CONSUMPTION[a]

ICBM Base	Consumption, gal
Minot	179,014
Ellsworth	170,235
Total	349,249

or 1164 gal per missile

[a]Oil consumption data includes oil used for heat, diesel motor generator set testing, and other equipment.

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